Impact Evaluation of

CIDA project 050/13155
SADCC project AAA.3.2.2

Power Supply to Northern Botswana (Kasane/Kazungula area)

FOR:

Canadian International Development Agency
Harare

Botswana Ministry of Mineral Resources and Water Affairs
Energy Affairs Division

SADC Energy Sector
Technical and Administrative Unit

ENERGY & DEVELOPMENT GROUP

CONSULTANTS IN THE FIELD OF ENERGY AND DEVELOPMENT

Rural Electrification

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Contract C9218
RC/Project 050/14328

Abstract

This report covers an impact evaluation undertaken on the electrification of the Kasane/Kazungula area in northern Botswana. The area was electrified in 1987. The impacts are assessed in terms of social, economic and environmental benefits. A baseline study, which was undertaken before the supply of electricity, was used to help assess the impacts. The report first describes the socio-economic context of the area, and thereafter the energy use patterns of different sectors of the economy are analyzed and compared with those described in the baseline study. Impacts of electrification arising out of the analysis are identified. A cost-benefit analysis is also undertaken to assess the project viability from a financial and economic perspective. Finally, recommendations to maximise the benefits of rural electrification are made, and the implications of this study on rural electrification policy are discussed.

for:

Canadian International Development Agency: Harare
Botswana Ministry of Mineral Resources and Water Affairs: Energy Affairs Division
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by:

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EXECUTIVE SUMMARY

1 INTRODUCTION

The Kasane/Kazungula area in northern Botswana was electrified in late 1987, with bulk power being supplied from the Zambian grid. A grant from CIDA paid for most of the electrification infrastructure. Both CIDA and the Botswana Ministry of Mineral Resources and Water Affairs wished to examine the impact of this project, and therefore commissioned this impact evaluation.

A 'baseline' study was undertaken in 1987 to determine the pre-electrification characteristics of the area, so that the impacts resulting from the electricity supply could be more clearly determined. The fieldwork for the current study was undertaken six years after that of the baseline study.

Objectives

Broadly, the objectives of the study were to determine the social, economic and environmental impact of electricity on the study area, to analyze any differences between actual and expected impacts, and to make recommendations on how to maximise the benefits of rural electrification projects in general. A cost-benefit analysis was also included to determine the financial and economic viability of the project.

2 PROFILE OF THE STUDY AREA

The study area is situated in the extreme northern corner of Botswana, where Zimbabwe, Zambia, Namibia and Botswana meet. The climate is relatively hot, and, in summer, wet. The area is located on the banks of the Chobe River. The economy of the area revolves around four main functions. These are:

(i) the area's role as the seat for the regional district administration, resulting in a large population of civil servants
(ii) its tourism trade, which, second to the state, is the largest employer
(iii) its situation on an important north-south tucker trade route, and thus businesses to support this activity have also developed
(iv) its function as a supply depot for surrounding rural settlements in Botswana, Zambia, Zimbabwe and Namibia.

There are two main settlement areas in the study area - Kasane, which has a population of about 5000, and Kazungula, which is more traditional in nature, and has a population of about 800. Kasane is a relatively modern settlement, with a commercial shopping complex and four residential areas. These are:

'White city'	-	State owned houses for their employees (127 houses)
Private river front	-	High income group, privately owned plots along the river (16 houses)
SHHA area	-	Self Help Housing Agency area, where plot owners build their own houses utilising SHHA loans for building materials (484 houses).
Plateau	-	The newest housing development in the area, comprising about 215 low, medium or high-cost houses.

Kazungula village has about 120 houses. The differences in income levels between settlements in the study area is marked, with SHHA and Kazungula settlements being the poorest, and the river-front households the wealthiest.

There are four tourist lodges in the study area, and one to the west of the study area in the Chobe Game Park. Other important business sectors include the wholesale/distribution sector, motor trade, and retailers. A significant small and informal business sector also exists.

The only commercial agriculture in the area is undertaken at Chobe Farms, the large Botswana Development Corporation farm (300Ha), and at a small poultry farm. One quarter of households are involved in small scale farming, mostly for subsistence purposes.

The area is relatively well serviced, with an adequate road system and an extensive water distribution network. One junior secondary school and two junior schools exist. Kasane has a well equipped hospital and a clinic. Communications in the area are well established.

Overall, the study area cannot be considered typical of rural settlements, mainly due to the presence of a large number of state departments and the relatively well established business sector.

Recent economic growth in the area

Since electricity connection in 1987, growth in the local economy has been significant, with government and private sector employment having approximately doubled (growth of 11.2 % p.a.), and total private sector turnover is estimated to have grown by about 9% per year.

An important contributor to the recent developments in Kasane were the large state development projects during 1991 and 1992, which cost over P 70 million in total. These projects accelerated economic and population growth, and drew work seekers from surrounding areas. The population is estimated to have grown at 8 to 10% p.a. during this period, but growth is now estimated at around 5% p.a. The recent drought also influenced the population growth, as rural dwellers migrated to centres such as Kasane in greater numbers.

The increased economic activity in the area has resulted in higher average household incomes when compared with those in 1987.

3 ENERGY USE AND THE IMPACT OF ELECTRICITY

Botswana Power Corporation tariffs and connection policy

Botswana Power Corporation (BPC) generally does not finance new connections. New consumers therefore are usually required to pay all connection and line extension costs incurred by BPC in bringing electricity to them. These costs are unaffordable for the majority of households. The Rural Collective Scheme is an alternative connection option where users approach BPC collectively, pay 40% of their connection cost up-front, and the state finances the remaining 60% over 10 years. This scheme has not been applied in Kasane.

BPC has six tariff categories: Domestic, Business 1, 2 and 3, Government, and Water pumping. Business 1 is for low-demand businesses, while Business 2 and 3 are for increasingly heavier demand operations. Only Business 2 and 3 have 'demand' charge components, the remainder of the tariffs only have 'fixed' and 'energy' charge components.

Electricity demand and growth in the Kasane area

The table below summarises the electricity use in the study area. It shows that the poorer residential areas and small businesses have mostly not been connected to electricity, while wealthier sectors are almost fully connected. This is because of the high connection costs that have to be bourn by the end-user. The overall domestic percentage connection (42%) compares well with many other parts of Botswana, although this is mainly because the state and BHC have paid for the connection of a large number of houses. In areas where users have had to pay for connection themselves (SHHA and Kazungula), the percentage connection is low.

Percentage connection of different sectors

	Median household income/month	No. elec users	No. houses/ departmts/ businesses	% electrified
DOMESTIC				
Kazungula	P 600	6	123	5 %
Plateau	P 1400	215	215	100 %
SHHA	P 742	14	484	3 %
Govt	P 1600	140	145	97 %
Pvt river front	P 4500	15	16	94 %
Other	-	43	43	100 %
TOTAL DOMESTIC	P 1056	433	1026	42 %
Larger business		42	46	91 %
Small business		3	33	9 %
Government		42	45	93 %

Electricity use in the Kasane/Kazungula area has been growing steadily, with energy demand growing 32% from 1992 to 1993.

Energy use by households

Household energy use varies amongst the different settlements, and is largely dependent on whether they have access to electricity. Wood, candles, paraffin and batteries are widely used in the largely unconnected SHHA and Kazungula areas, while these energy sources are used much less in the electrified residential areas. Gas is extensively used for cooking, even in electrified households. There is evidence to suggest that energy expenditures in electrified households is lower than for unelectrified households with similar incomes. While electricity is wanted by most of those still unconnected, the connection costs are usually unaffordable.

Benefits of electricity

The households which have connected to grid electricity are benefitting in terms of improved convenience, reduced expenditure, access to a greater range of modern appliances, improved lighting quality, and possibly improved health, partly due to the ability to refrigerate fresh produce.

Where electricity has failed to impact

Benefits of electricity have largely bypassed the majority of households, who cannot afford the connection fee. They remain without adequate lighting and dependent on inconvenient and more expensive energy carriers. This is probably the most significant shortcoming of the electrification project. It should nevertheless be noted that the proportion of unconnected houses is lower than in many other rural areas.

Increase in socio-economic disparities

Electricity is generally only used by the wealthier households, and has therefore served to increase the disparities between different socio-economic groups in the study area. This is illustrated amongst government employees, where the Permanent and Pensionable employees (who are usually in more senior positions) have benefitted from electricity, while the impact on the Industrial class employees has been low.

Energy use in community facilities

Energy use in community facilities is generally limited to electricity use. The junior secondary school is fully electrified, while only the staff accommodation at the two primary schools have electricity. The hospital is connected to electricity, and uses a great range of electrical equipment. Some areas have streetlights, although one of the areas in which they are most needed - central Kasane - does not.

Benefits of electricity

Community facilities such as hospitals and schools have benefitted from electricity, but to varying degrees. The increased ability to work at night is one of the major benefits for the hospital, while the school that is connected enjoys proper lighting and the use of other educational and office appliances. Community night-time activities have also been stimulated by electric lighting, such as recreation (bars, restaurants) and free movement due to street lighting in some areas.

Where electricity has failed to impact

Electrification has not realised its full potential to benefit community facilities because the primary schools have no access to electricity, and street lights have not been installed in central Kasane.

Energy use by businesses

In general, the larger businesses are often dependent on grid electricity for most of their energy needs, although gas is used for cooking in lodges and restaurants. Small businesses are mostly not connected to electricity. Before electrification in 1987, most larger businesses used generators as an electricity source.

Benefits of electricity

The benefits to connected businesses are significant, and it is estimated that this sector has grown by about 10% directly due to electrification. One of the main reasons for this development is the removal of capacity limits imposed by generators, reduced cost and improved convenience of grid electricity, and the ability to utilise a greater range of appliances. Increased refrigeration capacity, workshop equipment, office appliances and security lighting are some of the areas where electricity has been the most beneficial.

Where electricity has failed to impact

Most small businesses have not been able to afford the connection fee, in spite of productivity benefits which would result. The impact of electricity on connected businesses has also been restricted to some extent by the tariffs. Some business are not utilising security lights due to the

prohibitive electricity costs, while those with seasonal loads are particularly disadvantaged by the structure of the 'Business 2' demand tariff.

Energy use by government

Almost all state departments have connected to grid electricity, and are using it extensively. Four (out of forty-five) departments were encountered which were not connected. Few other energy sources are used by the government.

Benefits of electricity

The use of office appliances, cooling equipment and lights are amongst the most important applications of electricity. Also, some departments were using gensets before electricity connection, and thus are benefitting from the reduced cost, greater capacity and improved convenience of grid power over genset electricity. The level of impact for state departments is related to the availability of funds for appliance purchases.

Where electricity has failed to impact

A few state departments still await the approval of funds to connect, and are sometimes severely hampered by the absence of electricity.

Energy use by agriculture

The only farm with significant energy needs is the large commercial operation - Chobe Farms. This farm is electrified.

Benefits of electricity

Chobe Farms is benefitting from the use of electricity, as it allows more efficient irrigation and harvesting. Produce waste may also be reduced.

Where electricity has failed to impact

Small farmers have not been able to afford to connect, although electricity is not one of their priorities. The impact of electricity on Chobe Farms is also restricted to some extent by the tariff, which is considered excessive - particularly for water pumping applications.

Impact of electrification on women

The impact of electrification on women has been low, as almost all poorer households and small farmers have no electricity, and it is in these areas that women often are burdened the most with daily subsistence tasks.

Impact of electrification on the environment

The adverse environmental impact of electrification has been low, and is mainly limited to the cutting down of some trees during the construction of electricity lines. Impact on game and the visual impact on the area are generally considered low. The benefits on the environment have also been low, as energy use patterns in the majority of households remain unaffected by electricity, and therefore wood utilisation of the surrounding forests is almost unaltered.

4 FINANCIAL AND ECONOMIC ANALYSIS

Objective

The objective of the cost-benefit analysis is to assess the viability of the electrification project from a financial and economic perspective. The capital investments, expenses, receipts and benefits to date are all considered in the analysis. The financial analysis is concerned with the profitability of the project from the viewpoint of the Botswana Power Corporation, while the economic analysis considers costs and benefits to the broader economy. The economic analysis therefore includes a quantification of benefits to businesses, government, and households, and considers the CIDA grant funding as a cost to the economy. The financial analysis does not consider the grant as a cost.

The cost-benefit analysis is undertaken from the time of electricity connection (1987) to the present (1994), and is also projected to the year 2005.

Projected electricity use

Two scenarios are explored for the future growth of electricity demand in the area. Scenario one assumes levels of growth based on past trends - i.e. domestic connections remain low in most areas. Scenario two incorporates a shift in policy towards improving the access of all households to electricity, and thus a greater proportion of households are assumed to connect.

Results

The financial analysis shows the project to be clearly financially viable for BPC, and they are already making a profit. This profit is expected to grow significantly in future years. BPC would probably not have undertaken the project without CIDA support, as it is unlikely to have been financially feasible in this case.

The project is expected to result in a marginally positive economic return over the longer term. However, the benefits quantified in the analysis tended to be conservative, and if other powerful social benefits are considered in the evaluation, the viability of electrification becomes more clearly positive. The CIDA investment was thus worthwhile.

If a 'low connection cost, longer-term capital recovery' tariff was applied to the presently unelectrified houses, indications are that adverse effects on the financial viability of the project would be negligible, and BPC's profits would be affected minimally. The indication is that this is justifiable from a both a business and development viewpoint. The viability of such an intervention is, however, highly dependent on a number of variables, including the tariff design and the nature of the financing used.

5 RECOMMENDATIONS TO MAXIMISE THE BENEFITS OF ELECTRIFICATION

- Many households, small businesses and small farmers were unable to access electricity due to the high connection cost. A 'low connection cost, longer-term capital recovery' tariff, with capital redemption included in the energy charge, should therefore be developed and instituted to increase the connection rate. BPC is currently exploring appropriate tariffs to facilitate access to electricity.

- Low-cost technology can play an important role in reducing the capital cost of electrification and thus improving its accessibility. Pre-payment meter and ready-box

technology should be used in connecting households, and the feasibility of using other low-cost distribution or reticulation technologies should be explored.

- Many current and potential users were poorly informed about BPC electricity bills, tariffs and connection procedures. A BPC customer services facility in the Kasane area can help address this problem, as it will allow queries to be answered, misunderstandings to be addressed, and feedback to head-office on the needs of customers to be provided. It will also allow active electricity marketing to be undertaken.

- Electricity use in some businesses and by Chobe Farms is restricted to some extent by high tariffs, with applications such as security lighting and water pumping being considered particularly expensive. The potential to customise tariffs for specific applications such as these could therefore be investigated. The structure of the 'Business 2' demand tariff could also be reviewed, as it is particularly harsh on customers whose load varies seasonally.

6 POLICY IMPLICATIONS

The most important policy implications arising out of the study are summarised below.

- Rural electrification is unlikely to cause development in itself, but it can play a significant role in accelerating development if it is applied in a suitable context. If the connection cost is affordable, one of the most important factors affecting the uptake rate of a rural electrification (RE) project is the level of disposable income in a settlement. Signs that the area is already developing (production increasing, incomes rising etc.) are also promising indicators that electricity will be well utilised and thus impact favourably on an area.

- Much of the reason for the favourable impact of electricity on the Kasane area was due to the significant business sector, strong state presence, and general development taking place in the area due to its strategic situation on a trade route and in an attractive tourist area. This is atypical of much of rural Southern Africa.

- The application of RE in smaller, traditional settlements, where no sound business base exists and neither population nor incomes are increasing is unlikely to be viable.

- The Kasane/Kazungula project indicates that RE does justify subsidies in certain areas, as the economic benefits can be significant. In order to establish the scale of subsidy justifiable, however, a cost-benefit analysis will need to be done which includes discount rates and benefit weightings which reflect national priorities.

- It is essential to utilise affordable tariffs with minimum connection costs and long-term capital recovery components if impact on households is to be significant. This requires that capital costs be financed over as long a period as possible, and at favourable interest rates.

- The CIDA grant has been a success in terms of economic growth goals. A relatively high percentage of houses have also been connected to electricity, although the majority still remain unconnected. The poor in particular, who are an important developmental focus, are largely unconnected, and so have usually not benefitted directly. The project has therefore only been a partial success with respect to developmental goals. If widespread access is an important objective of such grants, then further measures may need to be taken to ensure that this happens. In the case of Kasane, this could have been achieved by direct CIDA involvement in reticulating and connecting households,

or by BPC, using suitable tariffs and technology. The latter approach is preferable, as it can be a financially viable undertaking, and therefore would fall within the utility's charge.

- Support strategies (information dissemination, marketing, appliance purchase schemes) should be considered with RE projects, as they can increase the rate of connection and consumption, and thus improve the economic viability of the scheme. In general, RE projects will benefit by being approached from the future users' perspective (i.e. looking at their needs and means), rather than concentrating on the technical and financial aspects of supply.

- Accessible tariffs and thus maximum household utilisation of electricity are also essential if benefits are to be felt by women, who are often principally belaboured with the daily domestic subsistence chores.

- If electrification is to address wood scarcity problems, it is of added importance that electricity tariffs are made affordable, as poorer households often utilise wood most extensively. Electricity may in any case not have a significant impact on wood scarcity on a national level, as settlements in which wood use is predominant may also be those where RE is least viable.

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NOMENCLATURE AND ABBREVIATIONS

ABC -	Aerial Bundle Conductor - a cost-effective overhead cabling system, where insulated run together in a 'bundle'. It is usually only used for low voltage applications, but can also be used with higher voltages.
ADMD -	After Diversity Maximum Demand - the total maximum demand of a group of households divided by the number of households. This will be lower than the peak demand of each house added together, as their peaks will not coincide.
Airdac -	A cost-effective cable system used for connecting households
BDC -	Botswana Development Corporation
BDF -	Botswana Defence Force
BPC -	Botswana Power Corporation
BTC -	Botswana Telecommunications Corporation
CTO -	Central Transport Organisation
DC -	District Commissioner
DDP -	District Development Plan, usually referring to Chobe District in this report
DEMS -	Department of Electrical and Mechanical Services
Genset -	Electricity generator set (petrol or diesel)
HV -	High voltage, usually over 33kV. In this project it usually refers to the 66kV line from Zambia.
IV -	Intermediate voltage - between LV and MV, usually 1000 to 3000 V.
LV -	Low voltage - 230 or 400V.
LSC -	Line Service Charge, a BPC scheme to recover costs of electrification
MV -	Medium voltage - 11kV in the case of the Kasane grid, but can be up to 33kV.
NDP -	National Development Plan
Nett energy -	The total energy in an energy carrier before any conversion inefficiency losses.
RCS -	Rural Collective Scheme, a government (BPC administered) scheme to reduce connection costs of electricity in rural areas
RE -	Rural electrification
SHHA -	Self Help Housing Agency
UPS -	Uninterruptible Power Supply
Useful energy -	The energy going to the application intended (equal to the nett energy times the appliance conversion efficiency)

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CHAPTER 6

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CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The Kasane/Kazungula electrification project

During 1987, the Canadian International Development Agency (CIDA) and the Finnish International Development Agency (FINNIDA) funded the electrification of the Kasane-Kazungula area in the northern extreme of Botswana. The funding covered an initial engineering feasibility study and electrical infrastructure construction. The latter included an HV connection to the Zambian grid, the construction of a HV/MV substation in Botswana, and an MV backbone through most of the Kasane-Kazungula area. No LV lines were included. The project was completed in January 1988 at a cost of US$ 3 million (in 1987 terms).

Evaluation studies

Prior to implementing the electrification project, it was decided to undertake an evaluation of the social, economic and environmental impacts of the electrification project as a part of the overall programme. This involved an initial 'baseline' study which was to be completed before the connection of electricity, and a follow-up study about five years after connection. The baseline study was to provide the necessary pre-electrification information such that the follow-up study could have a sound basis for identifying changes due to electrification. This report covers the follow-up study, the fieldwork for which was undertaken almost exactly six years after electrification project completion.

Cost-benefit analysis

Initially, this study did not include any formal cost-benefit analysis of the electrification project, as it was intended to identify the social, economic and environmental impacts of electrification in a more qualitative manner. However, during the course of the study, the scope was extended to cover a financial and economic cost-benefit analysis. This analysis has been incorporated into this report, and is presented as an integral part of the impact evaluation.

The aims of the original electrification project

No specific aims were identified at the time of the original electrification project, and therefore this evaluation could not assess impacts in relation to any such targets. The evaluation criteria assumed to be at the heart of the project were (i) economic growth, and (ii) developmental goals. The latter revolves largely around welfare and equity considerations.

1.2 OBJECTIVES

The object of rural electrification

An important aim of rural electrification is to provide energy services that can improve household welfare and stimulate production and commerce. If electrified, households can have access to the benefits that flow from the great range of electric appliances available on the market, such as high quality lighting (compared with traditionally used fuels), TV, radio, and eventually appliances such as stoves or hot water cylinders and 'kitchen' appliances. The most fundamental benefit for households is often considered to be the improved lighting. Often it is also thought that electrification can help ameliorate problems associated with other energy

supply options, such as fuelwood shortages and landscape denudation. Welfare can also be improved by the positive effects of electrification on community facilities such as water supply, health care, schools and community centres. Electrification can also stimulate production and enhance efficiency by offering improved lighting of the workspace and allowing the great range of electric machinery and appliances to be used (power tools, welding, electric pumps and motors, office equipment...). Also, it may be able to free up time from domestic chores such as wood collection, which can then be used in other more productive ways. The increased productivity, it is said, will raise disposable incomes and thus stimulate a cycle of economic growth in the area. In addition, electrification may result in reduced pressure on surrounding woodlands, or reduced emissions in households from fuels such as paraffin, and therefore have environmental and health benefits.

However, experience with rural electrification (RE) has shown effects to be very varied - sometimes disappointing, and sometimes positive. In addition, RE is relatively expensive due to typically long line extension distances and low population densities, and so demands a fair chunk of often scarce resources per capita. It is therefore of added importance that rural electrification projects be evaluated in order to assess the appropriateness of the resource allocation. This project comprises one such evaluation - resources have been committed to the electrification of Kasane/Kazungula, and their effectiveness in stimulating development is now being evaluated.

Broad objective of this study

The project Terms of Reference define the study objective as follows:

> *"The evaluation is intended to be a socio-economic and environmental study of the impact of the introduction of grid electricity to the Kasane/Kazungula area of northern Botswana. It is to include an analysis of the variation in actual from expected impacts, and the likely reasons for those variations, as well as an indication of lessons learned. The evaluation is also to include a cost benefit analysis which will assess the financial viability of the project both at present and as forecasted, and the economic viability of the project."*

Specific objectives of this study

In order to achieve the overall objective, a number of sub-objectives have been identified. These cover the social, economic and environmental impact evaluation, and extend this to comment on broader rural electrification policy implications for the SADC region in general. These are described below:

General impact assessment objectives

1) To examine the economic impact
2) To study the social impact at both a household and community level
3) To identify any impact on the environment.
4) To focus on the impact of electricity on women.
5) To analyze differences between expected and actual impacts in the above areas.
6) To identify constraints affecting electricity uptake rates and accessibility.
7) Isolate the effects of rural electrification from those of exogenous variables where possible

Objectives relating to future rural electrification policy, planning and implementation

1) Analysis of factors affecting accessibility (particularly connection policy), and identification of strategies to maximise uptake (including the role of information dissemination).
2) Analysis of tariffs used, and recommendations concerning tariffs for cost recovery and to maximise uptake.

3) Comment on the demand prediction methodology used, and recommendations to refine such predictions where feasible.
4) Comment on the technology used and potential suitability of other technologies available in Southern Africa
5) Extract any generalisable lessons from the area which can feed into an appraisal framework for the identification and prioritisation of suitable areas for RE.
6) Comment on the role of RE in relation to an integrated development strategy.
7) Summarise the implications of the findings on national RE policy in Botswana and RE funding in the SADC region.

Financial and economic cost-benefit analysis objectives

1) The **financial cost-benefit analysis** will examine the cash flow of the Kasane/Kazungula electrification project in order to allow an assessment of the financial viability of the project, both present and forecast. It answers the question "*Is the project financially viable*?". The following tasks fall within this objective:
   - To assess the current financial status of the project - involving a financial analysis of costs incurred and cost-recovery to the present.
   - To develop load forecast scenarios using existing demand trends. This will be informed by work undertaken in other parts of the project.
   - To undertake forecasts of project financial viability, based on the load scenarios developed, including sensitivity analyses of critical variables (e.g. discount rate, tariff used, uptake rates, etc).
2) The **economic cost-benefit analysis** will examine the project viability from the perspective of the broader economy in Botswana. The economic analysis uses quantitative data to addresses questions such as "*was the initial capital subsidy justified in terms of the benefits to the national economy?*" and "*what level of subsidy could be justified for RE projects of this nature*?". The financial analysis will be used as a basis for the economic analysis, but will include costs and benefits relating to the national economy. Where possible, these will be quantified, but, due to the nature of some of these factors, this will often be difficult.

Community feedback

Information relating to energy which is expected to be of use to communities will be disseminated. Useful information for households and businesses in the study area relates largely to electricity procurement and use, and therefore the feedback will focus on these aspects. Information pamphlets compiled for this purpose are given in appendix E.

1.3 METHODOLOGY

Information was gathered using a number of techniques. Household energy use information was gathered mainly by means of an extensive questionnaire survey. Participatory Rural Appraisal (PRA) techniques were also used to obtain information concerning household energy use patterns, focusing on wood use, and on the development of the settlement in general. Detailed interviews were undertaken to collect information on business and government department operation, and also were useful in gaining background information.

In total, 207 questionnaires were completed, 3 PRA exercises undertaken, and 76 interviews held. The full project information gathering and analysis methodology is explained in appendix A.

Household questionnaire survey coverage of the area

The questionnaire data is presented in this report in five categories:

Kazungula:	This includes the Kazungula village (120 households) and the nearby farming community of Kananga (3 households).
Plateau:	This covers the new housing suburb of the same name (215 households). Although some of these houses are government houses, they are included here rather than in the 'Government' category.
SHHA:	Included here are all the houses in the SHHA (Self Help Housing Agency) designated areas in Kasane (484 households in total).
Government:	This is principally made up of the government houses in 'White City' and the teachers' residences at Kasane Primary School (127 households in total), but also includes teachers residences at Chobe Junior Secondary School (18 households).
Private river-front:	This covers the private houses along the river bank in Kasane (16 households).

Other households: There are a number of other households associated with the prison, border posts, and Kazungula police station, and a few houses on private land along the river-front outside Kasane and Kazungula. These households were not included in the questionnaire survey, but some information on their energy use characteristics was obtained in other interviews. The new SHHA development on the Plateau is not covered by the survey, as at the time of the fieldwork it was unoccupied.

The processed questionnaire data tables are presented in appendix D, and more detail on most of the figures given in the report may be found in these tables.

The presentation of results

Questionnaire survey results are presented in the residential area categories explained in the preceding section. Where total figures are given for the entire sample, they are weighted according to the relative populations in each area. Weightings used are given at the beginning of appendix D. Where relevant, cost or expenditure information from the time of the baseline study (1987) has been expressed in 1994 terms. The average inflation rate over this period has been 11.75%.

1.4 CONSTRAINTS AND STRENGTHS OF THE STUDY

There were two major constraints of this investigation. Firstly, the baseline study did not provide a detailed and insightful point-of-reference from which to evaluate impacts. Secondly, the Botswana government has a policy of transferring people to different localities about every three years, and at most decision-makers remain in the same area for five years. This has meant that the impact assessment was severely limited, as none of the people who took decisions when the electrification was planned were still in the study area - all of them had been transferred a few years before. The people presently in the area had no idea of what the situation was like before electrification. It was thus difficult to make comparisons. People who had been resident in the area for more than five years usually did not have electricity in their own homes and were mostly in a supporting position in their jobs, which does not facilitate a deeper understanding of impacts.

The strengths of this investigation lie in the outstanding level of co-operation between the government employees and the researchers. Special mention here must be made about the excellent working relationship between the staff of the Energy Affairs Division of the Ministry of Mineral Resources and Water Affairs, the District Officer Lands, and the researchers.

1.5 STRUCTURE OF THE REPORT

Chapter two describes the study area in general, covering physical characteristics, development history and socio-economic characteristics. Current development priorities and constraints are discussed, and plans for further development described.

Chapter three covers the energy use characteristics of the different sectors in the study area, focusing on the use and impact of electricity. National energy use patterns and state energy policy are also briefly dealt with.

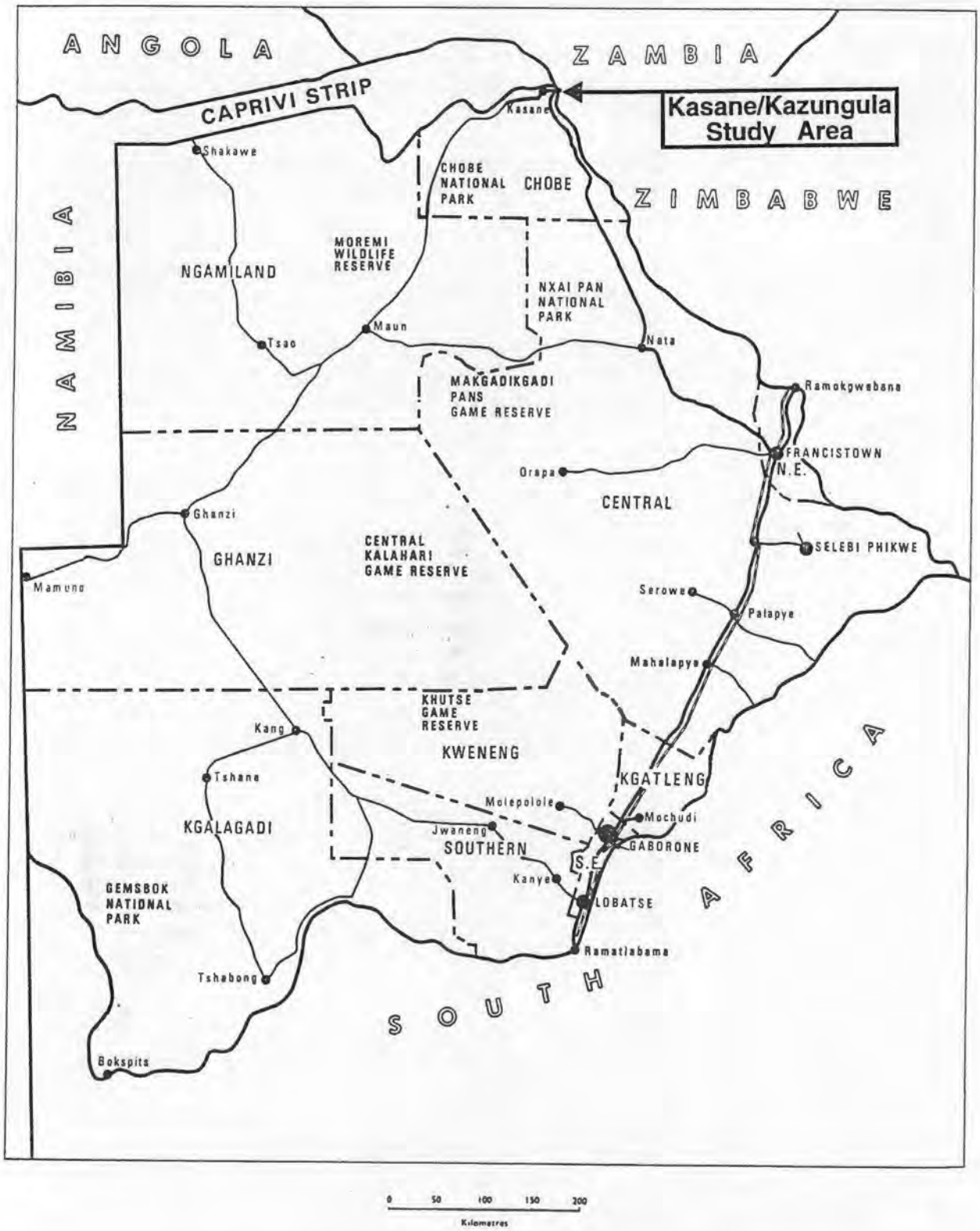
Chapter four then focuses on the impacts of electricity on the various sectors, and identifies areas where it has failed to impact. Current problems relating to electricity use are also discussed.

Chapter five covers the cost-benefit analysis. It describes the methodology used, applies it to the study area, and discusses the implications of the analysis on the viability of the project.

Chapter six discusses the implications of this study on rural electrification in general, and relates the findings to Botswana's energy policy. Recommendations to maximise the impact of rural electrification projects are also described, and the main conclusions of the study are summarised.

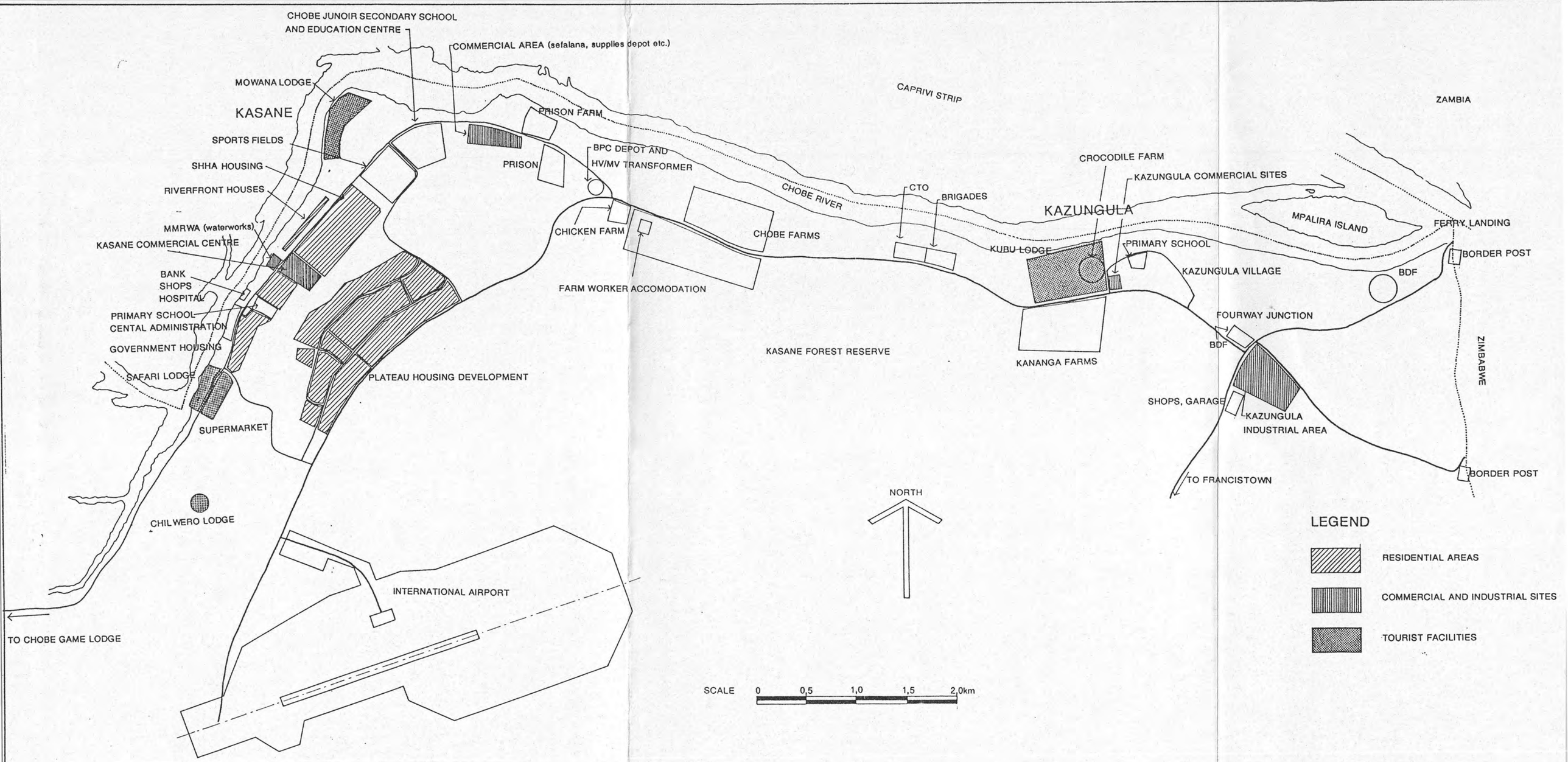
Map 1: Location of the study area within Botswana

(Source: NDP7)



CHAPTER 2

PROFILE OF THE STUDY AREA



MAP 2 : KASANE - KAZUNGULA STUDY AREA

CHAPTER 2

PROFILE OF THE STUDY AREA

2.1 OVERVIEW OF THE STUDY AREA

The area where the study has been undertaken is situated in the extreme north-eastern corner of Botswana, where it borders Zambia, Zimbabwe and Namibia. It has the highest and most reliable rainfall in all of Botswana, and is thus well wooded, with teak and mopane forests towards the south. Rainfall is principally in summer, and it is common for winter months to be without rain.

As the objective of this study is to cover the impact of the electricity grid supplied by the Zambian 66kV line, the study covers only areas in the immediate vicinity of the electricity lines. The study area is thus easily defined. It runs along the perennial Chobe River which forms its northern boundary. It is bounded by Zimbabwe in the east, the Kasane forest reserves to the south, and the Chobe Game Park to the west. It also includes the Chobe Game Lodge in the Game Park, as this is the furthest extent of electricity line to the west. The area is about 15km long excluding the Game Lodge, which is about 10km further to the west (see map 2).

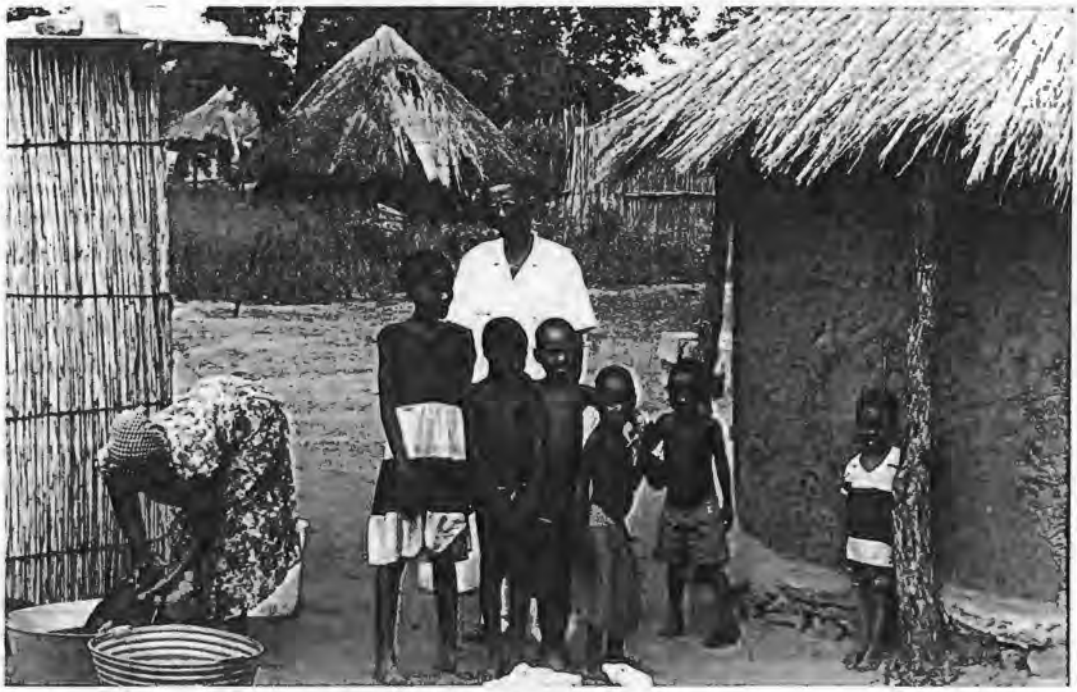
Most of the settlement is on the low land next to the river. Some of the newer residential developments and the new international airport are on the higher ground further south. There are two principle settlements in the study area - Kasane, which is a small settlement (population about 5000), and Kazungula, an older settlement, which is more rural and traditional in nature (population about 800). There are also a number of small residential pockets scattered along the main Kasane-Kazungula road. These are often associated with government bodies such as prisons, brigades, police stations etc. Kasane has a number of modern shops, a commercial centre, four distinct residential areas, and accommodates most of the central and local government administration for the Chobe district. Residents are mostly employed by the government and the tourist trade. The four main residential areas in Kasane are:

'White city'	-	State owned houses for their employees (127 houses). Called 'White city' because most houses are painted white.
Private river front	-	High income group, privately owned plots along the river (16 houses)
SHHA area	-	Self Help Housing Agency area, where plot owners build their own houses utilising SHHA loans for building materials and other assistance (484 houses).
Plateau	-	The newest housing development in the area, comprising about 215 low, medium or high-cost houses. Occupants are largely state officials or other medium to high-income families.

Recently, about 500 serviced plots on the Plateau have also been allocated, and are expected to be developed shortly. They will also fall under the SHHA scheme.

Kazungula has a limited commercial base, with a few small shops being the only local businesses. Inhabitants are often employed by state departments or commercial ventures elsewhere in the area. Many households utilise the nearby land for agriculture, mostly for subsistence purposes, although some produce is also sold. There are 120 houses in Kazungula village.

The Plateau residential area - modern houses, roads, streetlights and electricity.



Kazungula village - more traditional structures, with fewer services.

Government employees not in the main residential areas are accommodated at the Chobe Junior Secondary School, BDF camps, Kazungula police station, Zambian and Zimbabwean border posts, prison, Brigades, Central Transport Organisation (CTO) and the Chobe Game Park, which are located in the study area but outside of either Kasane or Kazungula settlements. There are also a few other private land holdings where households exist, mostly along the river between Kasane and Kazungula.

The Kasane area is linked to Francistown and Gaborone by a tar road (the latter is 1000km away). Other important links are with Victoria Falls, a major international tourist centre, and with Zambia in the north. Transport to Zambia utilises a ferry crossing at the point where the Chobe River meets the powerful Zambezi, just to the east of the study area.

The area cannot be considered typical of rural settlements in Botswana. This is partly because of the relatively high rainfall, but also because the traditional sector is not as prominent as the modern sector, at the core of which is the lucrative tourist trade and the central District Administration state offices. Nevertheless, the area provides an unusual mix of socio-economic characteristics, and therefore in many senses covers conditions in both modern and traditional rural settlements.

The economy

The area has a relatively strong economic base, which revolves around four main functions. These are:

(i) the areas role as the seat for the central district administration, resulting in a large population of civil servants

(ii) its tourism trade, which, second to the state, is the largest employer

(iii) its situation on an important north-south trucker trade route, and thus businesses to support this activity have also developed, particularly on the trade route (4-ways area east of Kazungula)

(iv) its function as a supply depot for surrounding rural settlements in Botswana, Zambia, Zimbabwe and Namibia.

2.2 A BRIEF HISTORY OF THE AREA

Development of Kasane and Kazungula

Kazungula settlement appears to have developed mainly during the 1960's, and is at least partially comprised of families who moved there from Zambia. In the early '50s Kasane was almost nonexistent, apparently comprising only 'a small DC's office and a policeman'[1]. The growth of Kasane is partly related to the settlement at Serondela (towards the west), which had developed around a timber mill. The mill closed in 1954, and the area was later included in the Chobe Game Park. Residents were expected to move out of Serondela, and many were granted land in Kasane as compensation, contributing to Kasane's establishment as a village. Early population growth is unknown, but Kasane was an established settlement by 1970, and the 1981 census shows the population to be 2190 (and 304 in Kazungula). One of the earlier settlement areas in Kasane was on the escarpment, now the Plateau area. In the early 1980's people from this settlement were moved down to the existing SHHA area to facilitate service provision. Although the SHHA settlement is relatively new, many of the residents have been in the area for a long time.

The Zimbabwean and Namibian independence wars

The Zimbabwean independence war, and to a lesser extent the Namibian war, affected the Kasane area significantly. In 1975 the Zimbabwean war escalated to such an extent that all links with Zimbabwe were cut, depriving Kasane of any tourism and access to supplies from Victoria Falls. The Chobe Game Lodge, which was important to Kasane's economy, also closed in 1977 due to the war. The Zimbabweans also bombed the Zambian ferry, thus severing the north-south transport links. However, Kasane soon became better connected with Francistown in the south and Katima Mulilo in the Caprivi Strip.

Drought

The drought in the late 1980s and early 1990s was another factor which influenced the development of the Kasane area. As the surrounding rural settlements could no longer depend on agriculture to support them during this period, the migration to urban centres such as Kasane increased. The population growth in the late 1980s is therefore partly a result of the drought.

[1] Source: interview with Mr Savas of Cool Joint.

An earlier drought - starting in the early '80s and ending in about 1986 - would also have influenced population growth in Kasane.

Recent development and state spending programmes

After the end of the Zimbabwean war (1980), the population has grown rapidly (averaging about 6% p.a.). The increasing local market and the probable increase in average incomes due to the presence of more salaried state employees, has facilitated the growth of the business sector. This sector now includes small 'shack' shops, general dealers, petrol stations, garages, building suppliers, bars, chemists, butcheries, clothes shops and bottle stores. A timber mill, which was established in 1983, and which was a major employer (220 employed), left the area in 1987. Electricity was brought to the area in late 1987, at a cost of P 5.6 million (P 12 million in '94 terms) funded mainly by grants.

Recent private sector developments

Some of the significant private sector developments since 1987 are:

- The construction of a major international tourist lodge - Mowana Lodge (cost approx P 37 million) - which increased the number of hotel beds in the area from 229 to 450.
- The expansion of Sefalana, the major wholesaler, which also moved from Kasane central to the commercial/light industrial zoned land opposite the road from Mowana Lodge.
- The establishment of a commercial centre (building) in Kasane central, which now accommodates clothing stores, a butchery, an electrical appliance shop, hair salon, and an office equipment supplier.
- Establishment of another drinks wholesaler/distributor in Kazungula.
- The upgrading of the local bank from a small agency to a more substantial operation.
- Establishment of transport related businesses in Kazungula industrial area (an import-export depot and a garage and filling station).
- A large Southern African safari operating company has also been set up in the area.

In addition, a number of smaller shops and businesses have been established.

The approach to Mowana Lodge - a large modern tourist destination on the Chobe River.

Kasane commercial centre building - which accommodates a clothing store, a butchery, an electrical appliance shop, hair salon, and an office equipment supplier.

Recent government developments

Recent state developments in the area have also been significant. A landmark in the development of Kasane appears to have been the targeted state spending on infrastructure development via the Accelerated Land Servicing Programme (ALSP). This programme aimed to "*address the problems of urban housing and serviced land supply*" and to "*provide the urban foundation, that will enable the growth of urban based manufacturing and services industry, providing employment opportunities to a rapidly growing population*"[2] and involved spending about P 28 500 000 in the Kasane area over the years of '91 and '92. The construction works undertaken in this time apparently employed all locally available labour, and more job seekers came to settle in the area - largely from the surrounding region.

The ALSP work involved:

- The construction of a sewage line & treatment works for Kasane.
- Servicing of 737 new residential plots on the plateau, and plots for a local centre and school on the plateau.
- Establishing and servicing 52 commercial plots in the Kasane CBD area.
- Establishing a commercial area in Kazungula with 28 serviced plots.
- Establishing an industrial area in Kazungula with 89 serviced plots here.

Services provided included electricity supply, water provision and road construction. The Plateau housing development was particularly significant as it increased the total number of houses in the area by about 20%. The serviced commercial plots in both Kasane and Kazungula are under-utilised, and thus the ALSP aim of stimulating economic growth by the provision of such plots has so far not been fully realised. The industrial plots in Kazungula have been better utilised (about 10 plots out of 89 are occupied), although the infrastructure provided is still largely idle.

[2] Accelerated Land Servicing Programme, Quarterly Report No.3, July 1st 1991.

Other significant state projects included the construction of a new airport in 1991/92 (at a rough cost of P 28 million), the reconstruction of the Nata-Kazungula road (costing about P14 million), and the upgrading of the ferry crossing to Zambia (cost about P 3,5 million)[3]. The total state spending on the area over the last few years has therefore been around P 71 million, which would have provided a massive boost to the local economy.

Some state departments have also established large operations in the area since 1987. The Supplies Department have set up a large depot to service the whole district, and BTC has built a large operations centre and microwave communications tower. With the increased BTC presence came significantly improved communication. Tourist operations are often particularly reliant on such communication and this is a factor which encouraged the establishment of at least one tourist venture in Kasane. Water Affairs also upgraded the water supply system, the Zambian border post was expanded to handle the increased traffic, and Civil Aviation and DEMS moved into the new airport. A BPC depot was established when the area was electrified.

In the early '90s the government decided to increase prices in Wildlife areas significantly in a high-cost, low-volume tourism policy. This appears to have affected Kasane, as some businesses mentioned that it had decreased the tourist volume to some extent.

[3] Source: DDP 4

Table 2.1: Some landmarks in the development of the Kasane region

PERIOD	EVENT
1930s & 40s	Agriculturally prosperous region
1950s	Heavy floods, causing diseases and forcing resettlement
1954	Serondela timber mill closed, some resettlement of residents in Kasane
1960s	Kazungula village developed substantially around this time
1971	Zimbabwean war started, but low key
1972	Chobe Game Lodge opened
1975	Zimbabwean war forced border closures Other trade links with Francistown and Katima Mulilo opened up
1977	Chobe Game Lodge closed due to war
1981	Census: Kasane population 2190, Kazungula 304
early '80s	Six year drought begins
early '80s	Current SHHA population resettled from escarpment to facilitate service provision
1983	Local timber mill starts up
1984	Chobe Game Lodge re-opens
1986	Chobe Junior Secondary School established
1987	Local timber mill leaves area Electricity provision in the area
1988	Upgrading of Kasane/Kazungula water system
late '80s	Recent drought begins
1991	Census: Kasane population 4934, Kazungula 906
1992/93	Large government spending projects (ALSP, airport, roads, etc.)
1994	Population estimate: Kasane 5574, Kazungula 975

2.3 ECONOMIC PROFILE

The economy in the study area is relatively dynamic. Both private and government sectors have shown a healthy growth in recent years, with small and informal businesses having grown the fastest. While these growth rates are high, they are similar to that of the rest of Botswana's economy (NDP7) which has been fuelled by growing diamond revenues, facilitating large public spending projects. Such state projects have also been important in the development of Kasane.

Table 2.2: Summary of the growth in the local economy from 1987 to 1994.

	1987 (baseline)			1994 (current)			% growth per annum - '87 to '94		
	number of business/ departmts	estimated monthly turnover (Pula)	estimated employmt	number of business/ departmts	monthly turnover (Pula)	employmt	number of business/ departmts	turnover	emplymt
Tourism/ hotel	5	1981900	246	7	2656900	432	5.3	4.6	9.0
Retail	11	242000	69	25	428500	95	13.5	9.2	5.0
Wholesl/ distributn	1	900000	16	4	2220000	49	23.8	14.9	18.8
Motor/ transport	1	110000	8	6	313000	52	31.7	17.5	33.4
Other	1	75000	14	2	145000	22	11.3	10.7	7.2
SUM business	19	3308900	353	44	5763400	650	13.8	8.9	9.8
Commrcl farms	1	1000	6	1	1000	3	0.0	0.0	-10.1
BDF farm	1	24600	55	1	51200	117	0.0	11.9	12.3
SUM farm	2	25600	61	2	52200	120	0.0	11.6	11.0
Small Business	5	7900	15	17	18790	32	20.7	14.3	12.4
Informal business	5	9500	5 *	15	27500	17 *	18.4	17.8	20.7
SUM small/inf	10	17400	20	32	46290	49	19.6	16.2	14.8
SUM all private	**31**	**3351900**	**434**	**78**	**5861890**	**819**	**15.3**	**9.0**	**10.3**
Govt (all)	30		300	45		647	6.4		12.6
SUM (pvt & govt)	**61**		**734**	**123**		**1466**	**11.4**		**11.2**

* - these estimates cover street vendors mainly, and exclude informal business activities in households

Notes: - '87 turnover in '94 Pula.

- '87 number of businesses/govt departments and employment estimated using baseline study, DDP4, and info from interviews on dates of business establishment. '87 turnover estimated using info from interviews on date of establishment of different businesses and changes in scale of operation over the period. '94 private sector turnover, number and employment obtained from interviews - in a few cases turnover was estimated based on turnover of other similar businesses. '94 government employment was estimated from info in interviews and increases in number of govt departments.

Business sector

The contribution of each sector to total turnover for the Kasane area is shown in figures 2.1 and 2.2, and the employment in figures 2.3 and 2.4. The importance of the tourism, one of the most important activities in Botswana, is apparent. Turnover from the wholesale/distribution businesses has increased significantly since '87, which is indicative of Kasane's growing function as a supply centre to the surrounding areas and countries. Another business sector that has grown considerably is transport related industry, presumably associated with increasing road-transported trade passing through Kazungula.

Sefalana - the largest wholesaler in the study area. It supplies the whole Chobe district and neighbouring countries.

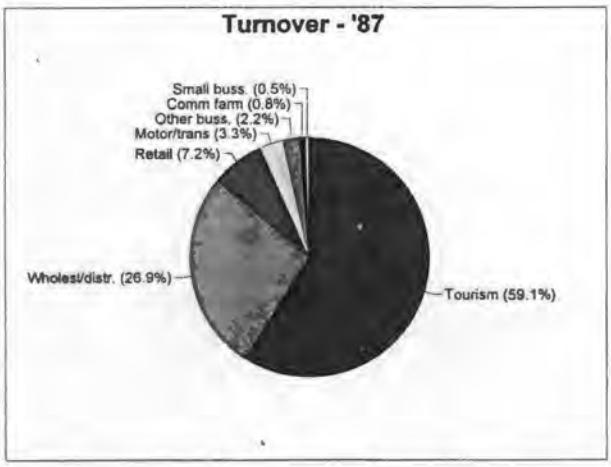


Figure 2.1: Private sector turnover in 1987

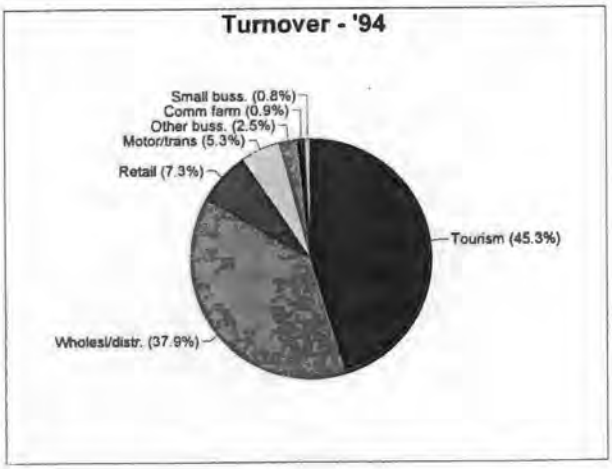


Figure 2.2: Private sector turnover in 1994

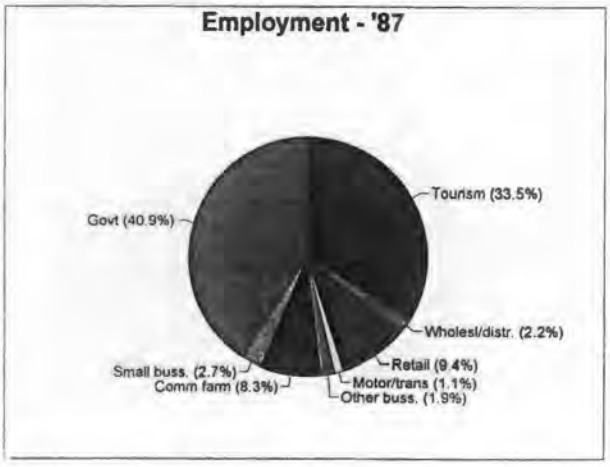


Figure 2.3: Total employment in 1987

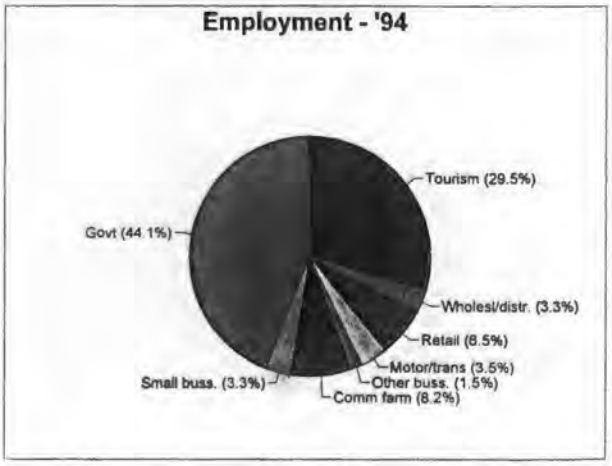


Figure 2.4: Total employment in 1994

Because the Kasane/Kazungula area has very little agricultural or other production, almost all supplies need to be imported, resulting in a significant amount of capital flow out of the area. In sectors which are large employers, such as tourism and government, wages provide a significant capital inflow into the local economy (about 14 % of private sector turnover is estimated to go to wages).

Small business and informal economic activities

About 30% of households are involved in some form of informal businesses. Figure 2.5 shows that tailors, food selling (and making), and fishing are the most common of such activities. A financial and advisory assistance programme for small businesses is operational in Kasane, and many of the most significant small entrepreneurs utilise this programme (Financial Assistance Programme of the Integrated Field Services government department). Amongst those involved in the programme are bakeries, sewing and knitting businesses, brick-makers, welders, carpenters, and fence makers. In total, there are about 17 of them.

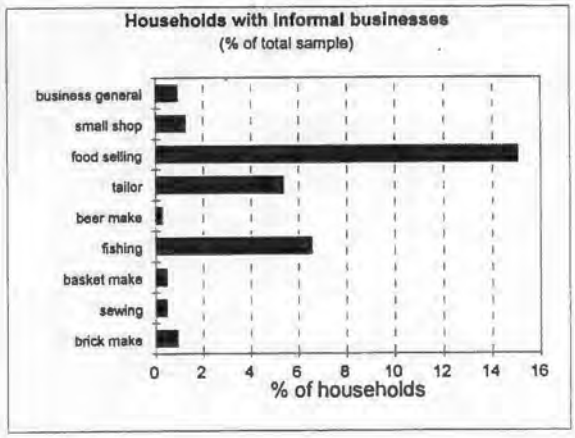


Figure 2.5: Households involved in informal businesses

A small shop operating from a backyard in the Kazungula settlement.

Agriculture

There is very little commercial agriculture in the study area. The main operation is the BDC farm ('Chobe Farms'). Its growth since 1987 has been significant, as shown in table 2.3.

Table 2.3: Growth of Chobe Farms since 1987

CHOBE FARMS	1987 (baseline)	1994
Area under irrigation	46 Ha	300 Ha
Labour force	about 30	about 110

Aside from the BDC farm, there is also a small poultry farm, selling both chickens and eggs (it started off with the chickens). A small commercial dairy which was operational at the time of the baseline study no longer exists.

A number of households are also involved in agricultural production (about 23%, mainly in Kazungula and SHHA). About half of these farmers obtain income from their farming, but it is a relatively minor contributor to total household income (see the section on household income).

Government

Kasane is classified as an urban area, and thus receives certain preferential treatment with respect to allocation of central government resources. There are approximately 45 government institutions in this area. Figures 2.3 and 2.4 show that the government's role in the area as the main employer is increasing.

Botswana has a system of government with both strong tribal and conventional administrative structures, and this is also echoed in government departments present in Kasane.

The District Administration office, which is headed by the District Commissioner (DC), is responsible for supervising the various central government departments in the entire Chobe District, although the different departments are responsible to their head offices, usually in Gaborone. Some of the other major district institutions are the District Council, who are involved with providing services to the local settlements and the district as a whole, and the Tribal Administration and Land Board, which administers tribal land and other tribal affairs. Kazungula is largely tribal land, whereas Kasane is state land.

There are a number of large state departments present which service the entire district, such as Supplies, Department of Water Affairs, and District Health. There is also a significant police and BDF presence due to the strategic location of the area, and two camps of Customs and Immigration officials - one at each border post. A full list of state institutions in the area is given in table 2.4.

Table 2.4: Government institutions in the Kasane/Kazungula area

Kazungula Police	Labour office	Library
Zimbabwe Border (Customs)	Justice Dept	SHHA Offices
Zambia Border (Customs)	Land Board	Post Office
Kazungula BDF camps (x2)	Water Affairs	Immigration & Tourism
Brigades	Council (CPO)	Court President
Supplies depot	Central Admin (DOL)	Tribal admin
Prison	Hospital	Tirelo Sechaba
Council depot	District Health	National Registration
Dept of Works (Bldgs)	Kasane Police	Livestock & Veterinary
Chobe CJSS	Integrated Field Services	Roads
Kazungula Primary	Forestry	Civil Aviation (Airport)
Kasane Primary	Agriculture	Meteorology Station
Education centre	Wildlife	Telecomms (Kasane)
Education Department	DEMS (at Airport)	Telecomms (Kazungula)
Non-formal Education	Info & Broadcasting	BPC

Government employees in Botswana fall into two distinct classes - the 'Permanent and Pensionable' class, and the 'Industrial' class. The former are usually skilled persons in relatively well-paid decision-making positions within the government, and are transferred every 2 to 5 years. The industrial class employees are generally employed from the local area, and are usually in lower-paid unskilled positions. In the Kasane area, the government housing and Plateau residential areas are largely occupied by Permanent and Pensionable state employees, while the Industrial class employees typically live in SHHA or Kazungula village settlements.

Unemployment

Unemployment levels can be difficult to define, particularly in areas where the informal sector is strong. The total formal employment in the area is about 1466 persons, and the unemployment rate of potentially economically active adults about 66%. If it is assumed that half of these are seeking employment, the unemployment rate would be about 33%. Against this needs to be weighed the involvement of 30% of households in informal activities, and household involvement in agriculture (23% of households are involved in agriculture and 14% derive incomes from this source). Overall therefore, this analysis does not clearly show unemployment to be a significant problem. Possibly a more reliably indicator of unemployment is that 18% of households mentioned the shortage of jobs to be a problem to them[4], particularly households in the Kazungula and SHHA areas.

2.4 SOCIAL PROFILE

Population characteristics

The exact population in the Kasane/Kazungula area is difficult to determine, with information from different sources sometimes giving contradictory figures. In addition, the information obtained from the questionnaire survey combined with the manual house count undertaken in this project suggest that the current total population is about 5200, which is 10% lower than that of the '91 census. As the main aim of the project was not to undertake a detailed population estimate, it will be assumed that the census figures are more reliable, and current population will be estimated using growth rates of 5% and 3% for Kasane and Kazungula respectively. These growth rates are considered reasonable when viewed in terms of the longer-term growth rates

[4] See the section on 'development priorities, constraints, and plans'

for the areas (as shown in table 2.5). The 1988 DDP4 growth estimates are higher (8-10% and 5% respectively), while the Central Statistics Office forecast a 3.2% growth for the area in 1987[5].

Table 2.5: Population growth and 1994 estimates

	'71 census	'81 census	'88 DDP4	'91 census	'94 (est)
Kasane	1463	2190	3165	4336	4898
surrounds				598	676
TOTAL	1463	2190	3165	4934	5574
%growth p.a.		4.1%	5.4%	16.0%	5.0%
Kazungula	327	304	496	757	815
surrounds			304	149	160
TOTAL	327	304	800	906	975
% growth p.a.		0.7%	14.8%	4.2%	3.0%
TOTAL (both)	**1790**	**2494**	**3965**	**5840**	**6550**
% growth p.a.		**3.4%**	**6.8%**	**13.8%**	**4.7%**
HOUSEHOLDS					
HH Kasane*	322	481	696	1084	1225
HH Kazung*	58	54	143	162	174
HH TOTAL	**380**	**536**	**838**	**1246**	**1399**

* - 4.55 persons per household are assumed for Kasane, and 5.6 for Kazungula

Age and gender

The baseline study found the population to be very young on average, with 54% of the population under 19 years of age (in 1981). This study found that about 37% of the population was under 19, and this was similar in all the residential areas covered. The population is thus not considered excessively young at present.

The gender characteristics of the population found in this study are similar to those of the baseline study: the baseline found 47% males and 53% females, while this study found 49% males and 51% females (the '91 census, however, found 54% males and 46% females).

Population dynamics

The population in the study area is highly dynamic. This is partly because of the recent high population growth rates due to the influx of work seekers and the drought forcing people from the rural areas, and also because of the high rate of transfer which is characteristic of government services (employees are often transferred every two to five years). Almost half of the present residents of the area at present were not here before 1987, as can be seen in table 2.6.

Table 2.6: Were you in the Kasane/Kazungula area before 1987?

(% hsholds)	Kazungula	Plateau	SHHA	Govt	Pvt river-front	ALL AREAS
yes	74	14	76	18	60	53
no	26	86	24	82	40	47

[5] Source: baseline study.

In the Kazungula and SHHA settlements most of the population are longer-term residents, as are most of the river-front population. The government figures from the table reflect the policy of transferring state employees frequently, and the Plateau dwellers are not long-term residents because it is a new suburb, and many are government employees. The impact of electrification on households was in fact quite difficult to assess, because residents in most of the electrified areas are the most transitory, and could provide no 'before' and 'after' comparisons.

As was found by the baseline study, the great majority of those moving to the Kasane area did so for work related reasons - either transferred by government, or to seek employment. While the baseline study found that most people that had come to the area were from within the district, now it appears that the majority of the people are coming from outside the district. This may be as a result of the increased proportion of state employees in the area (and thus increased transfers from other administration centres). Also, there has been an abatement in migration from surrounding areas due to the breaking of the drought and reduced employment opportunities in Kasane with the reduction in large state spending programmes.

Community services

Community services are generally the responsibility of the local council. Streetlights, roads, drainage and sanitation within the settlements all fall under their charge. A number of other government departments are also involved in the provision of services or other facilities to the community. Some of the more important community facilities or services are described below.

Education and training

Kasane has one primary school (to std 7) and one junior secondary school (to form 3), which was established in 1986 and is the only one in the Chobe district. Secondary school enrolment is currently 720 pupils. Kazungula has one primary school. There is also a relatively well equipped education centre in the area, which is involved in non-formal (adult) education and other training initiatives. The centre does not, however, appear to be meeting the further educational needs of many households, particularly in the SHHA and Kazungula areas, who feel that further education is not accessible to them. There are no senior school education facilities in the district, and those wishing to further their education must leave the area. The junior secondary school and the education centre are electrified, while the primary schools are not. Teachers are usually provided with accommodation at the schools, and in all cases these houses are electrified.

Technical training is provided by the Chobe Brigades parastatal, which is situated about 2 km west of Kazungula village. Training in carpentry, automechanics and welding is provided. Accommodation for the staff and trainees is provided on the premises. The staff accommodation, offices and workshops are all electrified.

Health

There is a relatively well-equipped hospital in Kasane (32 beds), and a small clinic in the SHHA area. Both the clinic and the hospital have electricity. The District Health Team is also based in Kasane, and services the rest of the Chobe district.

Water provision and sewage

The entire study area is supplied with water by the Department of Water Affairs. Their water processing station is in Kasane, and is driven by powerful electric pumps. Water is pumped to tanks on the Plateau, from where it is gravity fed to the different residential areas and to other users. The water reticulation system was upgraded to its present status in 1988.

Practically all households have access to at least a communal tap (figure 2.6), and 67% of households have either taps on their property (mainly in Kazungula and SHHA areas) or full house plumbing (Plateau, government housing and private river-front stands). A very small group of households living on farmlands near Kazungula village still fetch water from the river (this water is not considered fit for consumption).

While Kasane is largely served by a sewerage system, Kazungula is not. Here, and in the Kasane SHHA area, pit latrines are used.

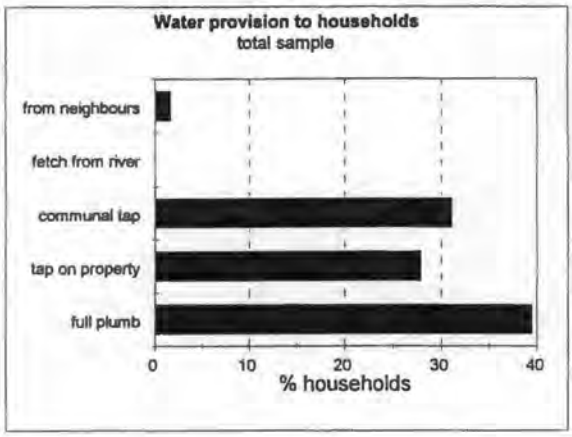


Figure 2.6: Water provision to households

Streetlights

All the areas serviced by the ALSP have streetlights. This includes the commercial and industrial areas, and the entire Plateau development, including the unoccupied sections. The SHHA area is currently having streetlights installed. There are no streetlights in the centre of Kasane, along the main Kasane/Kazungula road, or in Kazungula village.

Other services

There is a library in the Kasane commercial centre, which is connected to electricity.

Household characteristics

Size

While the baseline study found an average of six persons per household for the whole area, this questionnaire survey found 4.7 persons to be the average. The Kazungula and SHHA areas have more persons per household (5.6 and 5.9 respectively), while the Plateau and Government areas have fewer (2.6 and 3.1 respectively).

Employment

The employment profile of households in different areas is shown in table 2.7. Unemployment in SHHA and Kazungula areas are significantly higher than in the other areas.

Table 2.7: Average household employment profile

(persons/hh)	Kazungula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
self employ	0.13	0.06	0.16	0.09	0.6	0.1
skilled employ	0.22	0.15	0.16	0.39	0.8	0.2
unskilled employ	1.78	1.62	2.23	1.1	0	1.8
unemployed*	3.84	0.83	3.56	1.44	2.4	2.7
SUM employed	2.13	1.83	2.55	1.58	1.4	2.1

* - 'unemployed covers all persons without formal work at present, and includes the youth.

The state employs a significant number of women in permanent positions, and therefore amongst the government households, women are often the major breadwinners.

Income and expenditure

Household income and expenditure information is shown in table 2.8.

Table 2.8: Monthly income, expenditure and disposable income estimates

(Pula/hshold)	Kazungula	Plateau	SHHA	Govt	Pvt river-front	ALL AREAS
Av expend	364	917	403	598	2567	575
Av income	**999**	**1612**	**1467**	**1692**	**17800**	**1739**
Av dispos. inc	635	695	1064	1094	15233	1165
Median expend	218	655	270	400	2540	404
Median incme	**600**	**1400**	**742**	**1600**	**4500**	**1056**
Med. disp. inc	382	745	472	1200	1960	652

Notes: 1 Expenditure is difficult to determine accurately by questionnaire surveys, and these figures should therefore be regarded as indications of expenditure rather than reliable amounts. Smaller amounts spent during the month on groceries etc. are often not reflected in such a survey, and these could increase expenditure by 50 to 100%.

2 Expenditure *excludes* energy expenditure, and includes food, transport, rent, education and some other expenditure.

3 Income includes that from all sources - formal, informal and agriculture.

The income differences between different settlements are clearly quite marked, with Kazungula and the SHHA area being the poorest. In general, however, households appear to have reasonably high incomes compared with that of many rural settlements in Southern Africa. The income distributions for each residential area are given in figures 2.7 to 2.12. Incomes appear to be significantly higher than those found in the baseline study, even when inflation is taken into account. The differences are illustrated in figure 2.13.

Reasons for the differences could be that the income from the baseline study did not accurately reflect the actual incomes of households, minimum wage regulations coming into effect, or because of the increased economic activity in the area. The latter could have resulted in more persons per household earning incomes, or earning higher incomes in general. Growth in the economy in general, and particularly the increase in the number of government employees, is likely to account for most of this increase in average incomes (government employees are relatively well paid - average government households earn about P 1600 p.m.)

The sources of income for the whole sample are shown in figure 2.14. It can be seen that informal activities contribute very little to income in most settlements, but are not insignificant in Kazungula and SHHA areas. Household involvement in various informal businesses is shown in figure 2.5. Even though 23% of households in the area are involved in agriculture in some way, it contributes only minimally to overall income. Its value is therefore largely for subsistence.

Education

Table 2.9 shows that education levels in SHHA and Kazungula are lower than in other areas.

Table 2.9: Average household education profile (the table includes youth)

(% hh members)	Kazungula	Plateau	SHHA	Govt	Pvt river-front	ALL AREAS
none	40	4	35	13	20	25
primary	28	11	29	8	14	22
secondary	26	74	35	58	44	46
tertiary	6	11	2	21	22	8

Note on income distribution graphs: *The income groups increase in steps of P 500 - only every second income group is labelled on the X-axis due to space constraints.*

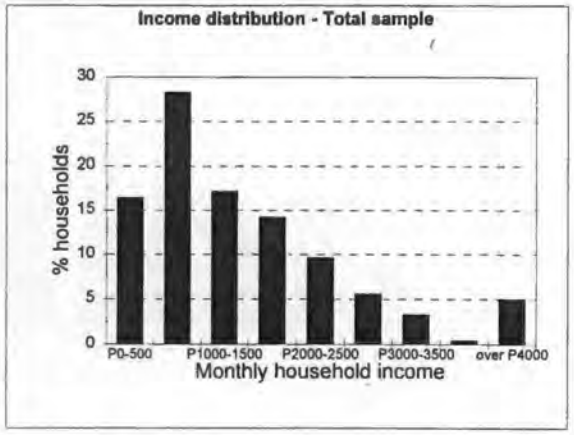


Figure 2.7: Income distribution - total sample

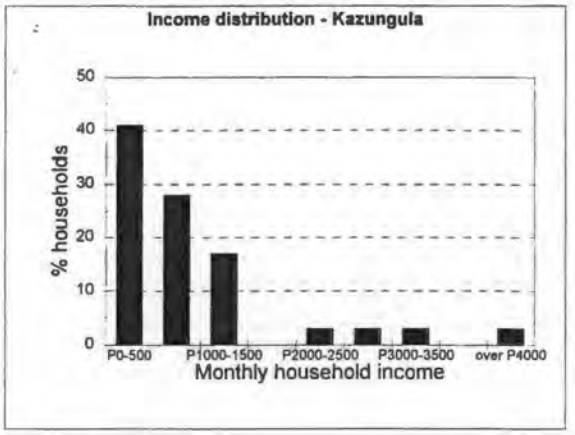


Figure 2.8: Income distribution - Kazungula

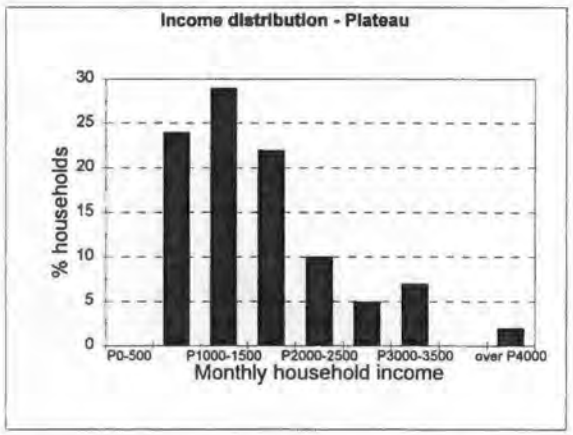


Figure 2.9: Income distribution - Plateau

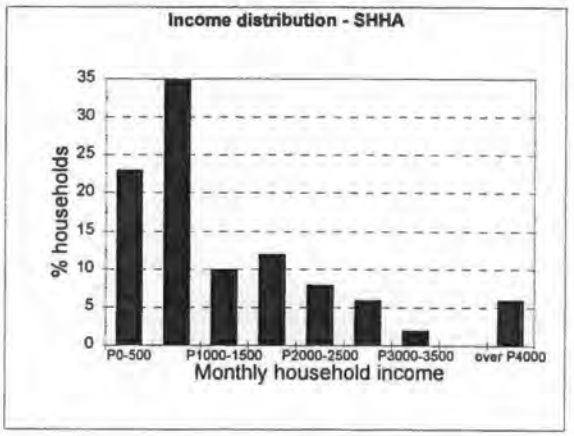


Figure 2.10: Income distribution - SHHA

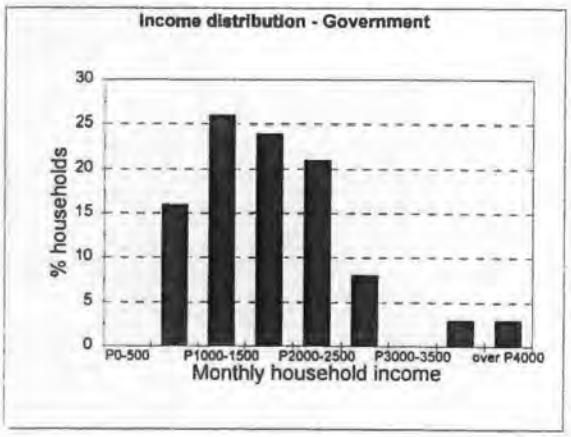


Figure 2.11: Income distribution - Government

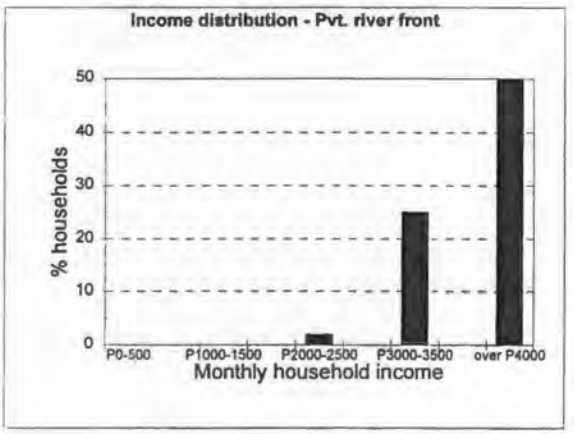


Figure 2.12: Income distribution - river front

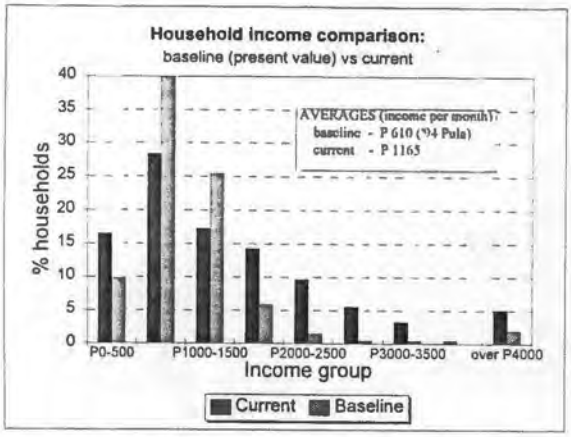


Figure 2.13: Income distribution- baseline vs current

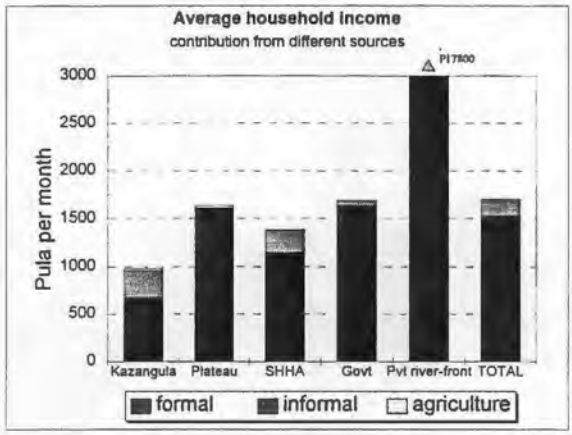


Figure 2.14: Sources of household income

Housing structures

The baseline study indicated that 59% of houses were of traditional construction (presumably mud, wood and reed). Now there are a larger proportion of block houses (see figure 2.15), indicating a clear preference for this construction type.

Plots in SHHA and Kazungula consisted of over three buildings on average, with many buildings having only one room, while households in the Plateau, Government areas and the river-front tended to have one larger building with five or more rooms each.

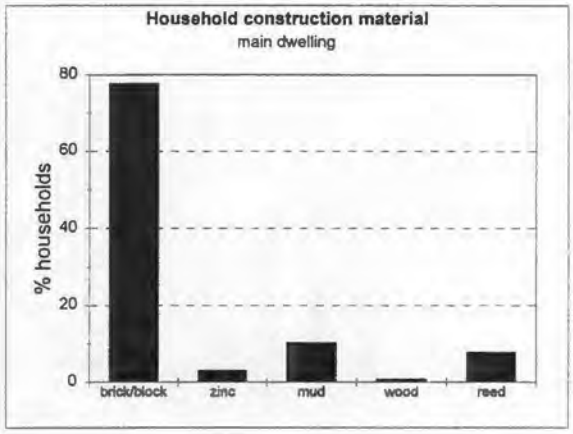


Figure 2.15: Household construction material

A house in the SHHA area. Households often comprise more than one building

Vehicle ownership

Vehicle ownership by households was found to be low in all residential areas (except the river-front households). On average 74% of households do not own vehicles.

Family roles

The family roles with respect to wood collection and involvement in agriculture were examined in this project. As was found in the baseline study, farming is still predominantly a female activity, while wood collection duties are more evenly shared by family members (see figure 2.16).

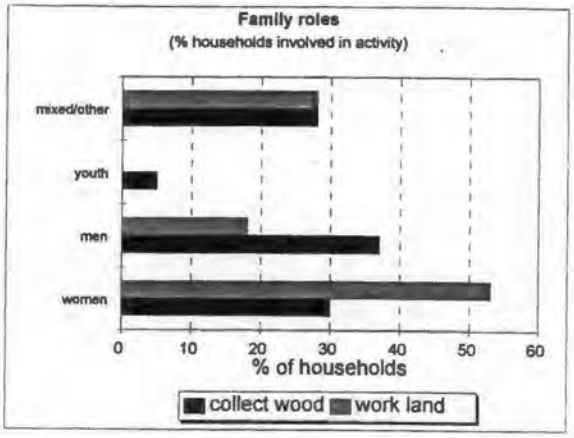


Figure 2.16: Family roles: wood collecting & farming

2.5 ENVIRONMENTAL PROFILE

The study area is a small urban development in a well forested area (there are approximately 4 000 sq.km of forest reserves), which abounds with game, including birdlife. The area has the highest rainfall of all the areas in Botswana. The peak rainfall period is in summer when thunderstorms often occur in the late morning or afternoon. Characteristic of the thunderstorms is the very dense cloud cover which leaves the area very dark. Average annual rainfall is 660mm.

The area is a well-visited tourist attraction as a result of the high nature conservation priorities: in the south there are the very densely wooded Kasane forest reserves, while the world famous Chobe National Park is in the west. Game wanders around in the urban areas and the local population see elephants as a problem to their safety as well as to the agricultural lands and vegetable plots.

Kazungula village - relatively well wooded.

2.6 DEVELOPMENT PRIORITIES, CONSTRAINTS AND PLANS

The problems and priorities discussed in this section not only assist in contextualising energy issues, but also provide information on where future state resources may be effectively allocated. The problems or priorities rated as most important are dealt with first.

Household development priorities and problems

The most significant problems relating to development as perceived by households were identified via the questionnaire survey. This may be used as a basis for establishing household development priorities. It is interesting to note that problems raised varied significantly amongst the different residential areas.

Cost of electricity connection

The cost of connecting to electricity was widely perceived as being unaffordable, especially amongst the largely unelectrified lower-income areas of Kazungula and SHHA. Although this problem was raised by a large proportion of households, it should be noted that this does not necessarily mean that it is their foremost priority:- because the survey related to energy matters, it would have come to mind more readily than other unrelated issues. It is, however, probably the most important energy issue for them.

Education and job creation

The need for job creation and improved education facilities (both for children and adults) also was important to residents, particularly in SHHA and Kazungula. The sense was that these households realise the importance of education in an increasingly modern town, and consider job opportunities to be related to education. But they cannot further themselves as they would have liked to because the area has no senior school or readily accessible adult education facilities. Also, once children have finished junior secondary school, they have to travel to centres such as Francistown if they are to further their education. The cost of this is beyond the means of many households. This problem of access to higher education facilities was raised in all residential areas, and overall may be considered one of the most powerful constraints experienced by households.

Access to residential plots

The lack of access to plots was also an important issue for many households, particularly in the SHHA and Kazungula areas, and the demand for plots has consistently outstripped the supply. Access to land was also mentioned in the baseline study as a major constraint to development. The problem may be that the land is too strictly zoned, and that these zones are not necessarily appropriate to the development needs of the area, as there does not appear to be any actual land shortage.

Expensive shops

Kasane appears to be a relatively expensive place to live in, as respondents from all areas considered food and other goods expensive. This may be as a result of the relative isolation of Kasane from major urban supply centres, resulting in high transport (and therefore retail) costs.

Threat from game (wildlife)

Another problem commonly mentioned related to being threatened by game when collecting wood or even when walking from one place to another. The need for streetlights also arose - to enable game to be seen at night, but also to discourage crime. The most serious problem affecting wood collection was mentioned as the threat of encountering wild animals while in the forests.

Recreation

Two problems mainly concerning the Plateau area are related to accessibility of shops (there are no shops in this residential area) and the need for recreation facilities (there are no bars or restaurants here either). The latter was also raised by respondents in government accommodation and also by some key residents interviewed, who felt that recreation facilities, for children in particular, were seriously lacking, and that this was precipitating social problems.

Theft and lighting

Residents along the river front mentioned that attempted break-ins were alarmingly frequent, and in some cases occurred at least once a week. Other areas also found theft to be a problem, and SHHA residents mentioned the need for lighting to discourage burglars. A relatively wealthy household near Kazungula had been burgled 47 times. The scale of the problem is thus clearly enormous. Street or other lighting is considered a critical part of further crime prevention strategies.

The figure 2.17 illustrates the problems raised by households in all residential areas. It should be noted that the high proportion of responses relating to the cost of electricity is likely to include a bias because of the energy focus of the survey.

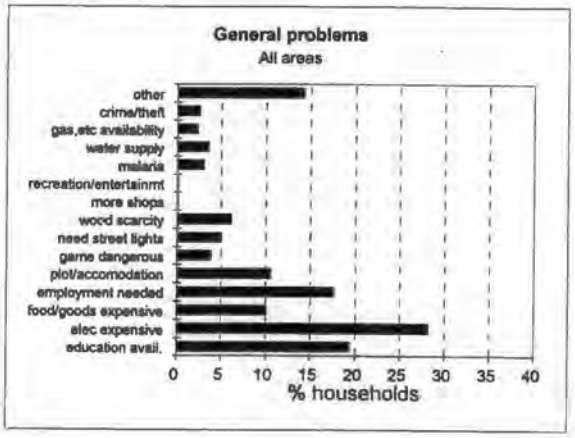


Figure 2.17: Problems raised by households - total sample

Problems experienced by businesses

Theft

According to many business owners, the most serious problem faced by businesses is theft. Apparently most of the offenders are Zambians who travel on the river, and thus businesses closer to the river are particularly vulnerable. From estimates given by businesses, it appears that currently about P 500 000 worth of goods may be stolen per year, which is a serious loss to the local economy, and one which it cannot sustain indefinitely. In addition, security personnel are employed by many businesses to prevent theft, which is a further drain on the economy (this is not entirely a negative impact, as it does create employment). To improve security, street lights and other security lights are considered essential (the main road in Kasane does not have streetlights at present). The cost of electricity for security lights is considered prohibitive by some businesses, and therefore not many such lights have been installed.

Demand charge on 'Business 2' tariff

Other energy related problems which clearly impact on economic development in the area concern the nature of the demand charge on all businesses in tariff category 'Business 2'. This demand charge is determined by either the maximum demand for the current month, or 90% of the maximum demand registered over the last 12 months, whichever is the greater. For seasonal businesses, such as the tourist trade, this results in high electricity bills even when operations are completely shut down. This tariff system was the cause of much complaint at a few businesses, and some are considering utilising their standby diesel generators to reduce their demand charges. The largest tourist lodge in the area has an expensive load management system, and thus they are less susceptible to this aspect of the tariff.

Connection fees

Connection fees were generally considered too high for most small businesses to afford. The benefits of electrification have therefore been limited in such sectors, and even large businesses have often waited several years before connecting. One venture, the crocodile farm, still has not connected, at least partly because of the high connection cost.

Supply of goods and fresh produce

Obtaining supplies of any nature is a problem in Kasane. Amongst the supply problems mentioned were building materials, welding gas, fresh produce and even petrol. Most goods are trucked from Francistown. Fresh produce apparently originates mainly from South Africa.

Sites for business establishment and expansion

Some businesses mentioned that they could not expand due to lack of suitable land. Although there are numerous industrial and commercial sites in the area, they are inappropriately located for some businesses. For example, a carpenter shop which moved from Kasane to an industrial site in Kazungula, has effectively lost most of its customer base because it is now too far away. As with the problem of access to residential plots, the problem may partly be one of inappropriate zoning rather than actual land shortage.

Labour shortage

A number of businesses mentioned that the lack of suitable labour in the area was a problem for them. As it is estimated that a reasonably high proportion of persons are unemployed, the problem may be that the necessary skills are not available, or that the willingness to work in the type of jobs available is limited.

Problems experienced by government departments

Problems experienced by government and other public service organisations mainly related to the sometimes severe shortage of office space and staff housing. Although most offices are electrified, where they are not, workers were clearly at a significant disadvantage. The system of transferring couples employed in government service independently was also raised on occasions as being disruptive to family life, although it appears that this practice has now been stopped. Also, teachers, whose homes had been electrified, complained that school electrification was not a priority for the education department (the two primary schools in the Kasane/Kazungula area have no electricity, while the junior secondary school is connected).

In more general terms, Kasane is relatively remote, and thus contact with central government is not always efficient. Also, having only 0.5% of the national population, it may also not be of high national priority. This is noticeable with respect to applications for funds to connect to electricity, which in some instances have taken several years to be approved, and in a few cases still await approval.

Problems experienced by farmers

About 23% (226 households) of all households are involved in agriculture, and these are largely in the Kazungula and SHHA areas. Agriculture is thus an important source of food and income to many households. The main problems experienced by farmers related to ploughing the land, the destructiveness of game in the fields, and the unreliability of rainfall with resulting insecurity in crop yields (see figure 2.18). Because of problems with game, a number of farmers in the Kazungula area have not bothered to plough their fields this season.

No private land is presently irrigated, and thus farmers are completely reliant on rainfall. It would, however, be a relatively simple task to pump water from the river, if appropriate technology was made available to them.

Chobe farms, the one large commercial farm in the area, has had difficulties in transporting goods to suitable market locations outside the study area. The lack of readily available markets has been an important factor contributing to the only marginal viability of the venture. They may now be purchasing a truck to try and address the problem. This is the only farm in the area that is irrigated.

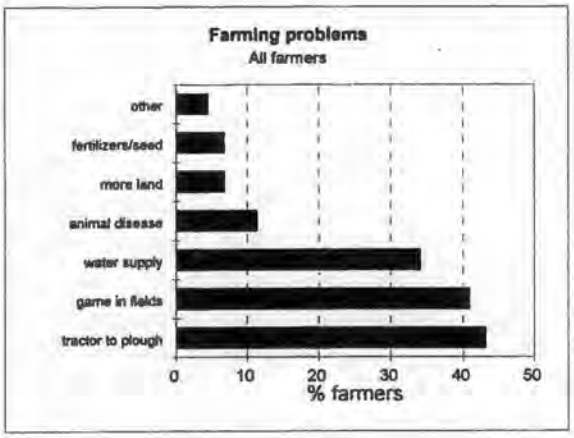


Figure 2.18: Problems raised by small farmers

General constraints on economic development

In addition to specific problems arising out of interviews with private and public sectors or the household questionnaire survey, a number of other constraints on the economic development of the region were identified. These are discussed below.

Although it is in Botswana's national policy to encourage the establishment of local manufacturing industry (via the establishment and servicing of industrial plots, for example), the scope for manufacturing businesses in the Kasane area appears to be limited. The local market is not substantial, and transport linkages with other potential markets or raw material suppliers are relatively poor (there is no railhead, for example). The same limitations also apply to commercial agriculture - i.e. important markets are far away and transport of produce is not easy. Also, competition from other areas, such as South Africa, limits the viability of many agricultural or industrial products.

Because Botswana's currency is relatively strong, the cost of labour and other goods tends to be lower in surrounding areas such as Zimbabwe, further limiting the competitiveness of locally produced goods. In addition, markets in nearby foreign regions are limited.

Development in Kasane generally may therefore be mainly in areas related to the local resources of tourism and possibly forestry, and also that stimulated by the presence of government employees and the BotZam highway. Significant development in the industrial or agricultural sectors is expected to be more limited.

Skewed development in the Kasane area

At present, development in Kasane is skewed, with socio-economic conditions in Kazungula village and SHHA being significantly poorer than for Government housing areas, the Plateau and the river-front. Almost all residents in poorer areas cannot access electricity, have significantly lower incomes, and are in general less educated than those living in other areas. Residents of these poorer areas also feel that they do not have access to adequate education facilities. They are not entirely without services, however, as there is reasonable access to potable water, and services in the SHHA area are being upgraded to include streetlights and better roads and drainage.

Synthesis of development priorities relating to electricity supply

A number of issues discussed above are either directly related to electricity provision, or can be ameliorated by electricity connection:

- Many households and small businesses have so far not benefitted from electrification of the area because the connection cost is often unaffordable.
- Street and security lighting is important in discouraging crime, which is a serious problem, and in allowing residents to see game at night.
- Electricity could facilitate water pumping for small farmers.
- The existing demand charge may result in high electricity bills for 'Business 2' consumers, and is particularly harsh on seasonal businesses, such as the tourist trade.
- Increased electricity connection to primary schools and houses may help improve education levels, which is currently considered a problem by many households.
- Recreation may be facilitated via widespread electricity provision, which would allow for more night entertainment centres and video shows, for example.
- Electricity can have a positive effect on currently unelectrified state offices.

Development plans

A number of new developments are currently underway or are planned. The most important of these are discussed in this section, and their potential impact on future electricity demand summarised.

Housing developments

The number of houses in the study area is expected to continue growing. Recently (November 1993) another 500 plots on the Plateau have been allocated, and there are apparently a few thousand more applications waiting to be addressed. Building has already begun on the Plateau plots, and it may reasonably be expected that house numbers in the study area may increase by about 500 over the next few years. Further increases in housing demand may be limited, however, in spite of the seemingly vast demand. This is because many of the applications are thought to have been made during the 'boom years' of '91 and '92, when construction work soaked up all the available labour and job seekers from the surrounding areas wanted to move to Kasane. Also, the drought will have pressurised people to move off their farms in the rural areas to centres such as Kasane. It is thus suspected that the actual current demand may be significantly less than number of applications, and house numbers may not grow rapidly beyond the 500-odd new houses for which plots have recently been allocated. Also, due to the current unemployment rate, the ability of the local economy to absorb large population increases may also be limited.

Private sector

A number of new business are in the process of establishing themselves or are currently under construction. Amongst these are:

- a furniture shop in Kazungula industrial area
- mini-supermarket in the Kazungula commercial area
- shopping complex near the Kasane commercial centre (to house five or more shops)
- truck repair business in Kazungula
- an electrical repair shop in Kasane commercial area

Other possible ventures mentioned included the establishment of a poultry farm, truck depot, butchery and a fish farm. In addition, many established businesses have plans to expand operations in some way. The general mood in the private sector is therefore optimistic.

The Plateau SHHA area - plots have recently been allocated, and building has started. The plots are serviced and the area is reticulated with an MV electricity network.

Government expenditure

Planned state projects of significance include the following:

- a new administration complex to house a large proportion of state employees in the Kasane commercial area
- street lights are currently being installed in the SHHA area, and roads and drainage are also being upgraded
- some upgrading of roads linking with other centres is also in progress

In addition, the DDP4 proposes the implementation of the following projects (pg 158):

- street lights along the Kasane-Kazungula road
- the connection of all government offices to electricity (only a few remain unconnected)
- electricity for Kazungula village (what exactly is envisaged here is not specified)

Summary of expected impact on electricity demand

While the scale of establishment of new businesses is significant, it is not considered very different to the growth in the economy over the past few years. In addition, none of the businesses being established or planned will be large consumers of electricity ('Business 3' tariff customers, for example). A large increase in electricity consumption is therefore not expected as a result of this growth in number of businesses.

The allocation of about 500 plots on the Plateau is likely to have some impact on the number of domestic consumers in the area. Although these plots are also SHHA plots, and therefore inhabitants are likely to have the same relatively low incomes as in the existing SHHA area, the area is already reticulated with MV lines and transformers, and thus it will be cheaper for households to connect. Domestic connections and therefore consumption is therefore expected to increase when this new residential area becomes established (plots were only allocated late in 1993, and therefore housing construction is very limited at present).

CHAPTER 3

ENERGY USE

CHAPTER 3

ENERGY USE

3.1 NATIONAL ENERGY USE CHARACTERISTICS & POLICY

Total energy consumption

The total energy consumption in Botswana is shown in figure 3.1. The role of fuelwood is apparent, and reflects the large consumption in the domestic sector, which accounts for over 50% of total national energy consumption. Other important energy users are mining, which is a major consumer of coal and electricity, and transport, which accounts for most of the petroleum product use. Government, manufacturing and agriculture all use less significant amounts on energy.

Domestic energy consumption

Approximately 44% of the total population of Botswana is in urban areas. Woodfuel is the most important energy source for households, particularly in the rural areas, but is also extensively used by urban households[6]. Fuels such as LPG (gas) and paraffin are also important sources of domestic energy, mainly in urban areas, and their use in increasing. About 30% of households are estimated to be connected to electricity in the urban areas, while rural connections are very low, with under 5% of households in electrified rural settlements being connected.

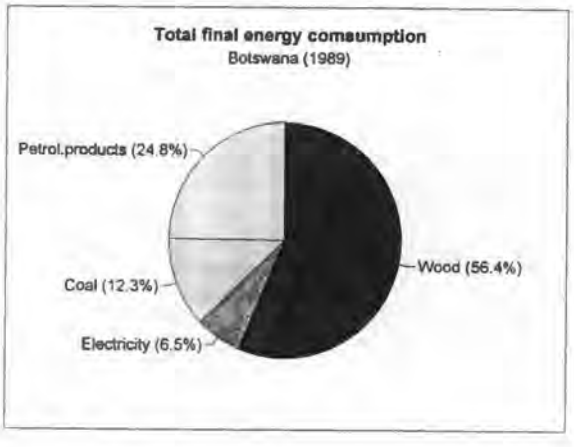


Figure 3.1: Total energy consumption in Botswana (Source NDP7)

Energy supply

Coal is largely obtained from one local mine, but some higher grade coal is imported from South Africa and Zimbabwe. Petroleum products are all imported. Wood scarcity, although not alarming, is already felt around towns and major rural settlements. In other rural areas indications are that wood use is sustainable at present.

Electricity is largely generated by the Morupule (132 MW capacity) power station. Another station at Selebi-Phikwe (65 MW capacity) used to generate power mainly for the local copper mine, but is now connected to the national grid. Some electricity is also imported via links with Eskom, a link with Zimbabwe at Francistown, and the Kasane/Kazungula Zambia connector (the latter is not connected to the national grid). About 10% of the total electricity consumption is imported, mainly from South Africa.

6 'Urban' in Botswana usually refers to settlements with populations of over 5000 (Central Statistics Office definition).

Electricity

Electricity generation and distribution is the responsibility of the Botswana Power Corporation (BPC) para-statal, which, in general, operates on a cost-recovery basis in-line with government policy. They are charged with the task of "generating and distributing power to all areas where it is commercially viable to do so" (NDP7).

The total national demand on the electricity grid is around 194MW, and total sales are 991 million kWh per year (1993). Of this, mining is the largest consumer (see figure 3.2). The total number of consumers is 32 000, with 26 400 of these being domestic (BPC 1993 annual report). Total installed line lengths are about 3000 km. Overall electricity consumption is estimated to be growing at 6.1%, with the domestic sector growing at 11.6% (compare this with the national population growth forecast of 3.7%).

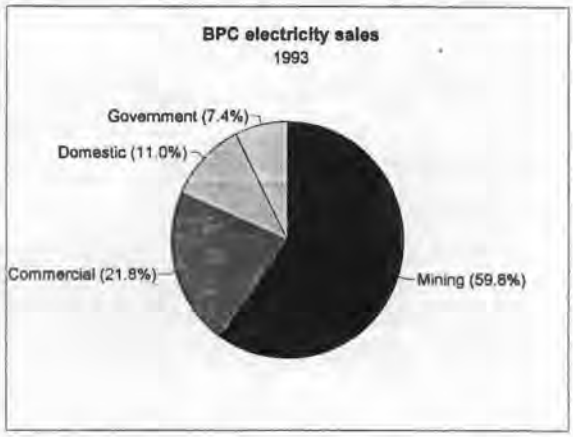


Figure 3.2: BPC electricity sales in 1993 (Source: BPC 1993 Annual Report)

While the national grid is relatively extensive, there are also some decentralised diesel generation plants supplying areas far from the grid. These are principally intended to supply state departments. In addition, the Zambian linked Kasane/Kazungula grid is not linked to the remainder of the national network.

Policy and plans

Important objectives of the state's energy policy (as expressed in NDP7) include:

- encouragement of manufacturing as a step to becoming less economically dependent on mining and to increase employment
- increasing access to suitable energy carriers in urban and rural areas, with specific attention given to low income households

Some measures mentioned in the NDP7 to address the central policy issues are given below:

- improvement of the distribution of commercial energy sources to rural areas (LPG, paraffin)
- encouragement of domestic coal use in order to alleviate the pressure on the wood resource
- intensification of rural electrification, including the establishment of decentralised diesel generation stations where grid extension is not feasible
- promotion of economically viable renewable energy sources in rural areas - solar in particular
- consider suitable electricity tariffs which will encourage use by the industrial sector, thereby assisting with the diversification of the nations industrial base

In addition, low electricity uptake rates are a concern, particularly amongst the domestic sector. Measures which have been considered to ameliorate this problem are:

- facilitating connection via measures to reduce the high connection payments. Rural Collective Schemes (RCS) are one such measure (explained later).
- full reticulation of new urban developments, rather than have BPC wait for individuals to apply before connecting them. The latter is considered "neither technically nor economically feasible" (NDP7). There is also apparently a move by government to increase reticulation of existing urban settlements as well.

3.2 BPC POLICY, TARIFFS AND OPERATIONS IN THE KASANE AREA

Financial operation

In general, BPC undertakes all projects on a financial recovery basis, with consumers paying for all infrastructure up front. They do not usually finance capital costs of new connections. Where projects are not financially feasible but are in keeping with government development policy, the state will provide BPC with the necessary funds to make it viable. In Kasane, for example, the state has spent significant amounts of money on reticulation in commercial, industrial and residential areas.

BPC is still considered by the government to be in the establishment phase, and state support is expected to decrease over time as BPC reaps the benefits of economies of scale and overcomes start-up investments. The longer-term aim is for BPC to be financially independent.

The Rural Collective Scheme (RCS)

New electricity consumers are normally expected to pay for the entire cost of connection up-front. This cost is unaffordable to a large proportion of households, and as a result the RCS was established to reduce the burden of this cost to the consumer. New users must pay 40% of the total cost up-front, and the state pays BPC the remaining 60%. This 60% must then be repaid by the consumer over the next 10 years. The interest rate on repayments is 9%. To qualify for the RCS, a minimum of four households must apply jointly.

In practice, the RCS is difficult to manage, often involving negotiations, quotes, further meetings, and finally implementation. Also, the 40% down-payment is still unaffordable to many households. Partly for these reasons, the RCS is not considered by BPC to be a long-term solution to the accessibility of electricity. No RCS projects have been implemented in the Kasane area.

The Line Service Charge scheme (LSC)

The LSC scheme is intended to improve the financial viability of supplying whole settlements with electricity. Its basic principle of operation is that users pay for their own connection and their share of the overall reticulation system up-front, and also pay the interest on the loan which covers the still unpaid for hardware (i.e. that for the users who have not yet connected). This way the project pays for itself from the start, with both hardware and loan costs being covered (although in practice BPC apparently often makes a loss on such projects).

It operates as follows: first, the reticulation is designed for the whole area. Each user who wishes to connect must then make an up-front payment of the total reticulation cost divided by the expected number of users (this is estimated as 70% of the total population). Connected users must also pay the interest on the loan covering the outstanding costs on a monthly basis. Such loan repayments are usually kept under P 50 per month. As more users connect, the outstanding balance reduces and so the interest repayments reduce accordingly. When 70% of the population has connected, the loan repayments cease.

A disadvantage of this system is that up-front payments are still high and therefore connection may be limited. As with the RCS, it is not considered by BPC to be a long-term solution to electricity accessibility. It is also difficult to manage.

Connection cost repayment terms

In some cases, users may be allowed to repay connection costs over time. This option is, however, not offered by BPC as a standard policy.

Tariffs

In 1988 BPC introduced uniform tariffs for the whole country, which until this time had differed from one area to another. The tariffs are meant to reflect the long-run marginal cost of supply. Tariff categories are shown in table 3.1.

Table 3.1: BPC Tariffs (effective from November 1993)

Monthly payments	Domestic	Business 1	Business 2	Business 3	Government	Water pumping
Fixed charge	P 7.00	P 17.00	P 17.00	P 17.00	P 17.00	P 17.00
Energy charge (per kWh)	P 0.2670	P 0.2770	P 0.1420	P 0.1280	P 0.3400	P 0.2825
Demand charge (per kW)	none	none	P 34.00	P 32.00	none	none

Note: Demand charge is calculated on the actual demand for the month or 90% of the peak demand over the last 12 months, whichever is the greater.

Definitions of tariff categories are as follows:

Domestic: All consumers using electricity supplied at 230V single-phase, or 400V three-phase, and not exceeding 60 Amps per phase - for domestic purposes only.

Business 1: All business consumers supplied with electricity not exceeding 400V, and in respect of loads not exceeding 35 kW.

Business 2: All business consumers supplied with electricity not exceeding 400V, and in respect of loads that exceed 35 kW.

Business 3: All business consumers supplied with electricity at or above 11kV.

Government: All government, municipal and street lighting installations.

Water pumping: A special tariff for consumers with water pumping applications.

Tariffs are still high relative to neighbouring countries, but may drop in future as economies of scale are realised. Generation fuel cost (coal) is relatively low, and therefore does not contribute to the relatively high cost of electricity. In general, tariffs have been increasing at rates lower than inflation (tariff increases from 1987 to 1993 have averaged 8.4%, while inflation has averaged 11.7% over this period). A tariff study is presently being undertaken for BPC, and future tariffs may be revised in the light of these findings.

Connection costs

It has been mentioned that all infrastructural costs are generally bourn by users. If the area is already reticulated (such as in the new Plateau SHHA plots or in the new industrial and commercial areas), connection costs are as follows:

single-phase 60 Amp (overhead): P 1135
three-phase 60 Amp (underground): P 3065

In addition, small administration and 'location factor' charges are added to the connection fee (12.5% and 1.25% of the capital cost respectively). The location factor varies with distance from Gaborone and Francistown, where the central supplies depot is located. The connection cost at the time of the baseline study for single-phase supplies was P 220, which is equivalent to P 485 in 1994 (taking inflation into account). Costs have therefore escalated at rates significantly higher than inflation.

If the area is not reticulated, users are usually required to pay for all the hardware from the nearest line to their stand in addition to the connection cost. The administration and location factor charges also apply to the total capital cost. Examples of typical costs which may apply to users are given below:

25kVA 11kV/230V PMT*	P 7400
25kVA 11kV/400V PMT	P 8800
400V ABC** line	P 3000 per 100m
11kV overhead line	P 3100 per 100m

** - Pole Mounted Transformer*
*** - Aerial Bundle Conductor*

Other hardware involved in connecting to 11kV lines may also have to be paid for.

A user 300 meters from an existing low voltage line may therefore be required to pay about P 12 000 (for a 3-phase supply), and if the nearest line is an MV line, additional transformer costs of P 7400 will be incurred. These costs are clearly unaffordable to all but relatively wealthy businesses, and therefore it makes sense to share these costs wherever possible amongst groups of users, as the RCS was designed to do. BPC is presently considering measures to assist customers in overcoming the high connection cost barrier, such as a long-term capital recovery tariff.

Technology

BPC is using some of the low-cost electrification technology available in Southern Africa. At present, ABC (Areal Bundle Conductor) is widely used for overhead LV lines, and 'Airdac' cabling is used for single-phase connections.

The use of pre-payment meters and ready-boxes are now standard practice in BPC. Although connection costs to the user are unlikely to change with the pre-payment meter/ready-box system, it does obviate the need for house-wiring. House-wiring is in any case no longer a significant hurdle to electrification, as suitable surface mounted cables are now available which are easy to install (often called 'surfix'). BPC is presently exploring the use of such cabling.

BPC environmental policy

No written environmental policy regarding the erection of power lines currently exists within BPC, although it is their stated policy to minimise environmental degradation. Environmental impacts are generally considered during project pre-feasibility studies, and people that are likely to be affected by the power lines are also consulted before project implementation. BPC intends to draft written guidelines in the near future.

BPC presence in the area

The main office for the Kasane area is in Francistown. BPC has a depot in the area which maintains and sometimes extends the local electricity network. They also connect new users. The depot is equipped mainly for technical duties, and has no marketing or revenue function. It is able to give quotes for simple LV grid extensions and connections, but more complicated quotes (e.g. MV extensions) are referred to Francistown. Francistown also handles all the billing, which sometimes results in delays, particularly when responding to customer queries.

BPC has plans to set up a revenue office, and possibly a commercial office (which will handle marketing amongst other things) in the Kasane area, although this may not happen in the short term.

The existing grid and electricity use

The grid

The electricity grid in the study area is shown on map 3. It comprises the following:

- a 17.5 km 66kV feeder connecting to an existing grid in Zambia
- a 2x2.5 MVA 66/11kV substation
- 28 km of MV (11kV) overhead line running
- 8.6 km of MV underground line feeding lodge in the Chobe Game Park
- 10km of LV (400V) line

The total value of the distribution network is about P 15 000 000 in '94 terms (the initial CIDA grant covered most of this).

Demand increases over time

The electricity demand in Kasane is still increasing for almost all tariff categories (see table 3.2). The 'Business 3' category no longer has any consumers - it is likely that one of the construction companies in the area during the 'construction boom' of the early '90s would have used electricity at this tariff.

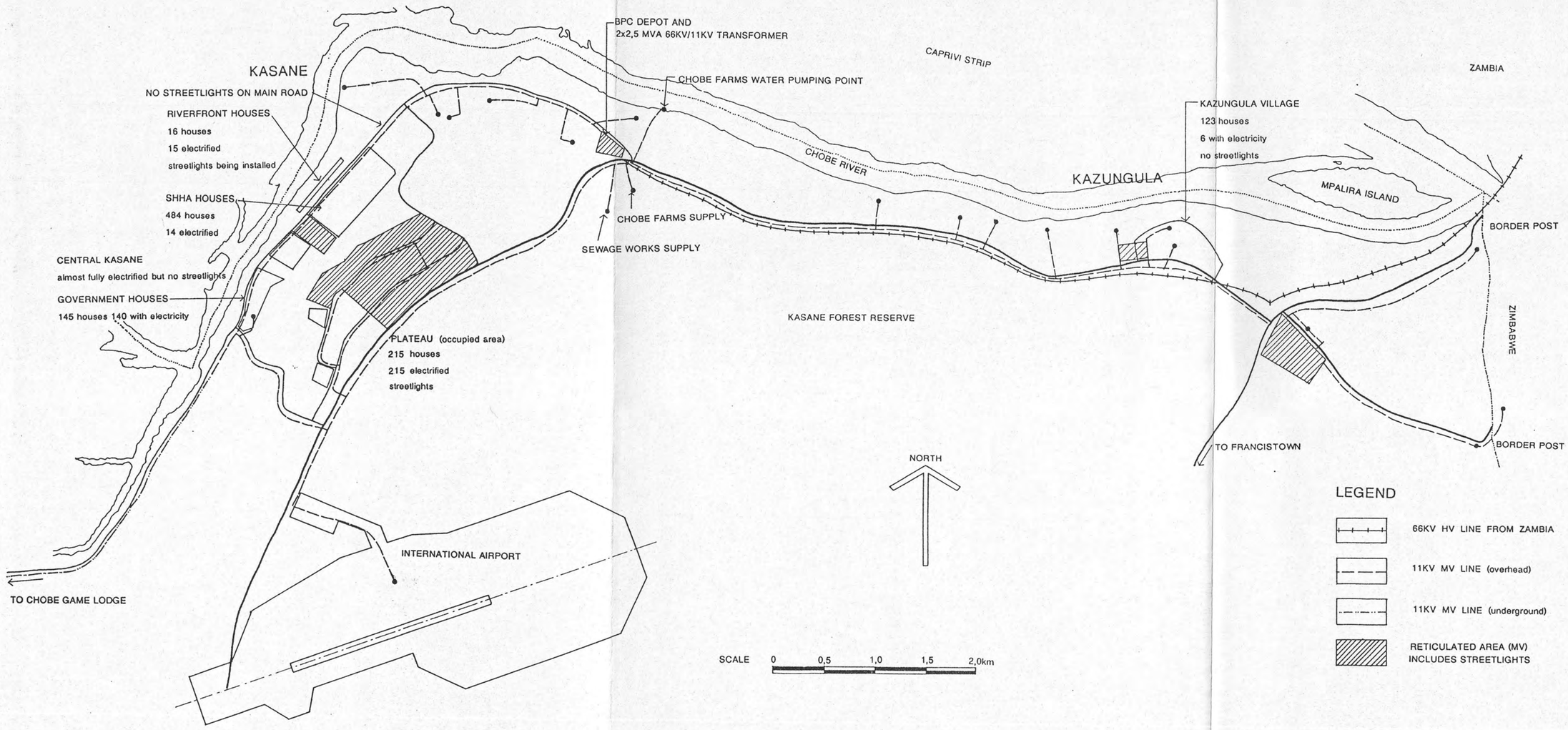
Table 3.2: Electricity demand increase of the Kasane grid (kWh)

year	domestic	bus 1	bus 2	bus 3	Govt	TOTAL
'88	5116	865	55680	0	0	61661
'89	57927	97319	778192	0	223422	1156860
'90	122542	226410	818610	16000	183864	1367426
'91	251515	327082	944034	63000	256400	1842031
'92	384202	511057	890529	1100	486934	2273822
'93	559271	690170	1110020	0	642290	3001751
Av. growth p.a.	156 %	281 %	82 %		30 %	118 %
'92-'93 growth	**46 %**	**35 %**	**25 %**		**32 %**	**32 %**

Source: BPC Gaborone

The number of consumers is the area is also growing, largely due to the increase in domestic consumers (see table 3.3). There was a jump in the number of domestic consumers from '92 to '93 due to the connection of all the Plateau houses in '93 (215 houses). It is interesting to note that many government departments, including the central District Administration offices, took several years to connect and many departments only connected in the last two years. Even now, Justice, Meteorology and the CTO (Central Transport Organisation) have not yet connected to electricity.

At present (Feb 1994), there are 6 consumers in the 'Business 2' category, of which one is a para-statal (Chobe Farms). A number of state departments utilise 35kW or more, but are charged at the 'Government' tariff. The major electricity users in the area are given in table 3.4.



MAP 3 : KASANE - KAZUNGULA ELECTRICITY NETWORK

Table 3.3: Increases in number of consumers on the Kasane grid

year	domestic	bus 1	bus 2	bus 3	Govt	TOTAL
'88	4	1	3	0	0	8
'89	21	10	4	0	8	43
'90	51	15	5	1	15	87
'91	108	19	6	1	21	155
'92	168	24	6	0	23	221
'93	398	32	5	0	56	491
Av. growth p.a.	151 %	100 %	11 %		63 %	128 %
'92-'93 growth	**137 %**	**33 %**	**-17 %**		**143 %**	**122 %**
'94*	433	57	6	0	63	559
'93-94 growth	9 %	78 %	20 %		13 %	14 %

(Source: BPC Gaborone) * - The '94 figures are based on counts of users billed during January 1994.

Table 3.4: The large power users on the Kasane/Kazungula grid (Jan 1994).

	Tariff	kWh/mth	kWh charge	Demand kW	Demand chrg	TOT charge
Mowana Lodge	Buss 2	115800	16460	311	10574	27034
Game Lodge	Buss 2	36500	5200	105	3570	8770
Safari Lodge	Buss 2	21800	3113	66	2244	5357
Water Affairs	Govt	15264	5224			5224
Chobe Farms (1)	Buss 2	11240	1613	63	2142	3755
Kubu Lodge	Buss 2	11160	1602	28	952	2554
Telecomms	Govt	10960	3743			3743
NW distr.council	Govt	10761	3692			3692
Zimbabwe	Bus 1	8000	2233			2233
Chobe Farms (2)	Bus 1	7666	2140			2140
Customs & Exc.	Govt	6739	2325			2325
Sefalana Whlsl.	Buss 2	4800	699	65	2210	2909
Pvt (1)	Bus 1	4767	1337			1337
Pvt (2)	Dom	4031	1083			1083
Carl. Bro Int.	Bus 1	3976	1082			1082
Kasane Hospital	Govt	3880	1336			1336
Sesheke Bar	Bus 1	3847	1082			1082
Chobe trading	Bus 1	3611	1017			1017
Chobe butchery	Bus 1	3401	959			959
Low-Price Store	Bus 1	3380	953			953
Supplies Dept.	Govt	3120	1077			1077
Barclays Bank	Bus 1	2840	803			803
Chobe Brigades	Govt	2720	941			941
Prison	Govt	2498	866			866
Airport	Govt	2400	833			833
Centre Bar	Bus 1	2295	653			653
Telecomms Kaz.	Bus 1	2120	604			604
Bamba-Z. Dealer	Bus 1	2040	582			582
Chobe CJSS	Govt	1840	642			642
Pvt (3)	Dom	1545	419			419
Chobe services	Bus 1	1504	434			434
Afro Ventures	Bus 1	1340	388			388
Ass.Council Sec	Govt	1295	457			457
Pvt (4)	Dom	1225	334			334
Education Cent.	Bus 1	1200	327			327
MPS Botswana	Bus 1	1180	344			344
Info& broadcast	Govt	1141	404			404
Police Kasane	Govt	1136	403			403
Pvt (5)	Dom	1086	297			297
Squires	Bus 1	1009	296			296
TOTALS		**327117**	**67997**	**638**	**21692**	**89689**

Not many businesses in Kasane fit the 'Business 2' tariff category (demand over 35 kW), and those that do are larger businesses usually not constrained by the capital cost of connection, and thus connected early. Note that despite the small number of 'Business 2' consumers, they constitute a large proportion of total demand (40%).

Table 3.5: Increase in peak load on the system

Year	Peak MW	Month of peak
'89	.300	Oct
'90	.400	Sept
'91	.480	Nov
'92	.700	Oct
'93	1.060	
Av.growth p.a.	38 %	
growth '92-'93	51 %	

The peak demand on the system has been increasing in keeping with the demand increase (table 3.5). It is noteworthy that the demand peaks in summer. This is because most of the major consumers are tourist lodges (see table 3.4), and therefore their peak electricity demand corresponds with the peak tourist season.

Percentage connection

The percentage electricity connection per sector is given in table 3.6. The difference in access to electricity in relatively low-income non-government households and in small businesses compared with wealthier state housing and larger businesses is marked.

Table 3.6: Percentage connection of different sectors (1994 estimates)

	No. elec users*	No. houses/ departmts/ businesses	% electrified
DOMESTIC			
Kazungula	6	123	5 %
Plateau	215	215	100 %
SHHA	14	484	3 %
Govt	140	145	97 %
Pvt river front	15	16	94 %
Other**	43	43	100 %
TOTAL DOMESTIC	433	1026	42 %
Larger business	42	46	91 %
Small business	3	33	9 %
Government	42	45	93 %

* - number of electricity users for govt and businesses may not correspond with those in table 3.3, as the latter sometimes has several accounts for one state department, or one account for two businesses etc. Also, this table includes estimates for '94 where information was available.

** - this includes houses at border posts, prisons Kazungula police station etc.

BPC marketing in the Kasane area

There has been no specific marketing strategy aimed at the Kasane region, although meetings may have been held with residents on the arrival of electricity advising them of connection costs and supply application procedures.

Actual vs predicted connection rates & energy demand

Baseline study take-up rate indications

Although the baseline study made no take-up rate or load demand increase predictions, they examined the likelihood of different users connecting to electricity based on 'willingness to pay' information from the questionnaires. They estimated that without loan finance, only 1% of domestic users and 35% of commercial ventures were willing to pay the connection charges.

In residential areas where households have had to pay for their own connection, take-up rates have been very low as predicted. Although the take-up rate for small businesses has been low, if all businesses are considered together, the connection rate is presently about 57%. In very general terms, therefore, the 'willingness to pay' indicators given by the baseline study seem to have provided a rough indication of actual take-up rates in the short-term, but do not predict longer-term trends well, as user perceptions and willingness to pay change over time as the benefits of electricity are observed. Changes in the economy may also affect connection rates.

Feasibility study load forecasts

The feasibility study on the Kasane/Kazungula link with Zambia performed a more detailed load forecast to determine the line capacity required (SADCC, 1985). The forecast was made to the year 2001. Existing diesel generators were used as a basis for determining the likely future demand in commercial, agricultural, industrial and government sectors.

Assumptions made include:

- no growth in hotel demand assumed
- the sawmill was included in the forecast, although it left the area before electricity was connected. Its demand was assumed to be 300kW growing at 5% p.a.
- government sector assumed to increase over the first 3 years and thereafter remain stable at 313 kW.
- other industrial growth is assumed to be 5% per year, starting at 50kW
- agricultural demand is due to Chobe Farms irrigation (1 kW/Ha), and grows according to the farm's expansion plans (30Ha to 150Ha over 5 years)

For the domestic sector, the following was assumed:

- 3.5% population growth (although this was considered conservative)
- 70% of households were low income, 15% middle income, and 15% upper income
  Demands were assumed as follows:
  - low income: 50% connection over 10 yrs, with a 200W ADMD[7]
  - middle income: 100% connection over 10 yrs, with a 750W ADMD
  - high income: 100% connection over 5 yrs, with a 1500W ADMD

Load factors were also estimated for the different sectors, such that energy sales could be predicted. The average load factor for all sectors was around 43% for 1993. The forecast for 1990 and 1993 is compared with the actual energy demand in table 3.7.

[7] After Diversity Maximum Demand - the total maximum demand of a group of households divided by the number of households. This will be lower than the peak demand of each house added together, as their peaks will not coincide.

Table 3.7: Predicted vs actual energy demand for 1990 and 1993

	1990	1993	'90-'93 growth p.a.
Predicted peak kW	1240	1470	6 %
Actual peak kW	400	1060	38 %
Predicted MWh/year	4717	5643	6 %
Actual MWh/year	1367	3002	30 %

The predicted growth rates are shown to be well below the actual growth rates, and if this growth continues, the actual demand will soon exceed the predicted demand by a significant amount. The energy consumption estimates are much higher than the actual consumption. This is partly because of the high load factor assumed in the estimates (around 43% on average - 25 to 30% would probably have been more reasonable). The high load factor was assumed because of the high constant demand expected from appliances such as airconditioning at lodges. In practice, lodge loads are very seasonal, and the only lodge with airconditioning has a complex load management system. Also, the sawmill promptly left the area after the forecast had been made - this would have reduced their forecast by about 950 MWh per year (and the forecast peak demand by about 400kW).

Further observations concerning the load forecast are:

- although growth rates in consumption and demand are higher than was forecast, the start-up was much slower than expected. State funds to connect departments often took several years to be approved, and other sectors also connected more slowly than anticipated.
- the household ADMD is considered rather arbitrary, and is probably much too low (it is common practice to design supplies to low-income households for 1.5 kVA ADMD or more). This contributes to the low demand increase predicted.
- household uptake rate has been significantly different from the predicted uptake due to the relatively prompt connection of all government houses, and the extremely low connection rate in Kasane and Kazungula as a result of the high connection costs.
- the population has been increasing faster than the estimated 3.5%, and commercial sector growth has also been higher than the assumed 5%.

Elements to a more comprehensive demand forecast

The above points suggest that the following could assist in improving load forecast accuracy:

- Connection costs need to be considered in relation to incomes if realistic demand estimates are to be made. This applies particularly to lower-income businesses and households.
- Economic growth and population growth need to be studied more carefully in load forecasts - taking national average estimates can result in inaccurate predictions. Past trends in the area are likely to be more appropriate (if available). Also, consideration of significant state funded projects or private sector developments can provide useful indicators of future growth.
- The delay in approval of state funds can delay connection of government departments for a number of years.
- Only the larger businesses can be expected to connect immediately after electricity becomes available. Smaller businesses (e.g. shops) may only connect a few years later, if at all (the connection cost is a strong influence here).

Substation capacity saturation

It is interesting to note that the peak demand in the area will reach the capacity of the substation in about 15 years if the demand grows at 10%, and about 30 years if it grows at 5%.

3.3 HOUSEHOLD ENERGY USE CHARACTERISTICS

Energy sources

Figures 3.3 to 3.8 illustrate the sources of energy utilised by households in different settlements as well as for the entire sample. Figure 3.3 also shows differences between fuel use at the time of the baseline study and the current survey. Overall, there is a wide range of energy carriers used, with 40% or more of households using wood, batteries, candles, gas, paraffin and electricity. Car batteries are less widely used, and gensets are uncommon. The main differences between household use now and in the baseline study is that paraffin and candles are less commonly used now, and gas use is much more prevalent. The differences are largely attributable to the availability of electricity, which will have reduced the overall use of candles and paraffin for lighting, and also because of the increased number of state employees in the area, which would have increased the gas usage, as many government houses have gas stoves.

Energy use patterns are very different in the various settlements, as is shown in figures 3.4 to 3.8. In the Kazungula and SHHA areas, wood, candles, batteries and paraffin are all widely used, although paraffin use is less prevalent in Kazungula. Gas is used by over half of the households in SHHA, but by under 20% in Kazungula.

In the wealthier and electrified areas of government housing, private river-front stands and the Plateau, batteries, candles wood and paraffin are not commonly used. Not all the government houses are connected to electricity because in one area above the main government residential area there are some temporary structures in which state employees live while they await formal housing, and these do not have electricity. One house was encountered along the river-front without electricity. At present it is being rented, and the owner has been away for some time and has therefore not connected[8].

Wood use is covered in more detail in later sections.

Different uses for the energy sources

Table 3.8 shows what the different energy carriers are used for. In electrified houses, the main use for electricity is lighting, while many households also use electricity for radios and hi-fis (stereo). About a third of electrified households also use electricity for fridges, ironing and TV. In houses without electricity, paraffin and candles are principally used for lighting, and batteries are used in radios and TV. It is not surprising that in electrified residential areas, paraffin, candle and battery use is low. Households using paraffin for lighting also often use it for cooking, while gas is used almost exclusively for cooking. The latter is reinforced because government houses are usually supplied with gas stoves.

The table also illustrates the versatility of electricity - i.e. electricity can be used for a great range of applications, while other energy sources are less versatile. This is often one of the major reasons why electricity is sought after.

[8] When viewing figures relating to the river-front households it must be remembered that there are only 16 stands, and questionnaires were completed at 5 of these. One questionnaire is therefore 20% of the total sample here.

Table 3.8: Uses of energy carriers for the total sample (households using the energy source)

(% hshlds)	light	cook	heating (space or water)	radio/ hi-fi	TV	torch	iron	fridge	electronic equip.
electricity	99	8	14	72	27	0	29	30	0
paraffin	98	38	1	0	0	0	1	0	0
gas	2	99	11	0	0	0	4	9	0
candles	100	0	0	0	0	0	0	0	0
batteries	18	0	0	87	0	16	0	0	1
car batts	0	0	0	100	0	0	0	0	0
genset	100	0	0	0	0	0	0	0	0
wood	0	100	0	0	0	0	0	0	0

Expenditure on energy

Energy expenditure by households is shown in table 3.9. It is noteworthy that in SHHA and Kazungula, battery expenditure is significant, and although paraffin is widely used in these areas, relatively little is spent on it. The same applies to candles. In areas where electricity is used, expenditure on electricity accounts for the major proportion of total energy expenditure. Expenditure on gas is also significant where it is used. The amount spent on obtaining wood in the SHHA area is noteworthy, as it reflects on the difficulty of accessing the resource. It is interesting that the relatively wealthy electrified areas of Plateau and the government housing spend less on energy than those in SHHA, where the median income is significantly lower. This strongly suggests that energy expenditure is reduced by access to electricity. Overall, therefore, the indications are that electrification effectively obviates the use of candles, paraffin and batteries significantly, and is likely to reduce total energy expenditure.

Table 3.9: Household energy expenditure (for the total sample)

(Pula/hshold per month)	Kazungula	Plateau	SHHA	Govt	Pvt river-front	ALL AREAS	Baseline* ('94 Pula)
electricity	9	47	4	36	133	21	0
paraffin	6	0	7	1	0	4	6.5
gas	4	22	24	32	22	22	12.0
candles	8	0	7	1	0	5	4.6
batteries	14	2	26	3	1	15	8.9
car batts	1	0	1	0	3	1	0
genset	0	0	2	0	0	1	?
wood	5	0	32	0	0	16	7.54
TOTAL	**47**	**70**	**102**	**72**	**106**	**84**	**39.5**

* - obtained by re-processing the original baseline survey data, and converted to '94 Pula using the average inflation rate (11.75%) over this period.

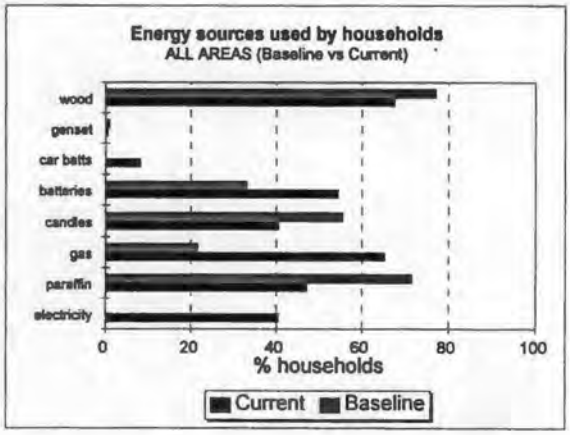


Figure 3.3: Household energy sources: total sample (baseline vs current)

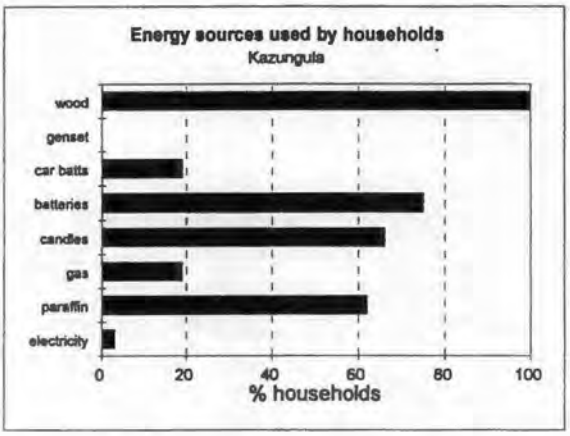


Figure 3.4: Household energy sources: Kazungula

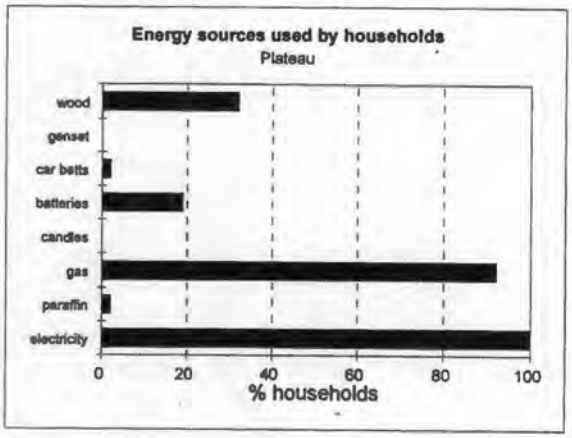


Figure 3.5: Household energy sources: Plateau

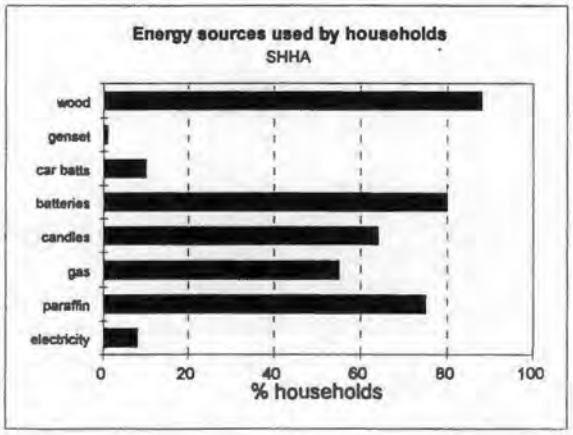


Figure 3.6: Household energy sources: SHHA

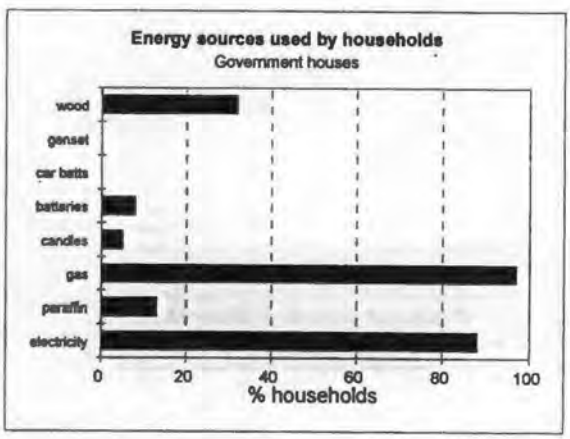


Figure 3.7: Household energy sources: Government

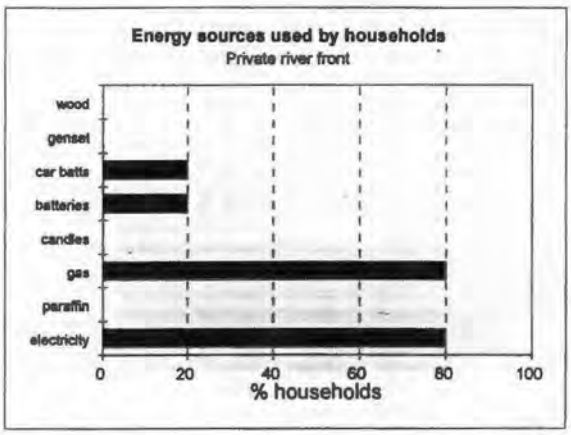


Figure 3.8: Household energy sources: river front

The expenditure information obtained from the baseline data set (adjusted to '94 Pula) indicates that energy expenditure was considerably lower during 1987 than is currently the case, although the average expenditure is not very different to that of Kazungula at present. Amounts spent on paraffin and candles are not significantly different, while expenditure on gas and batteries have increased. Increased energy expenditure is probably linked to the generally higher incomes in the area when compared with the baseline study (note that prices have, if anything, risen at a rate lower than inflation, therefore the increased expenditure is not due to more expensive fuels).

Energy expenditure as a proportion of income

The expenditure on energy as a percentage of total income is given in figure 3.9. Although this percentage is not as high as is found in many rural areas, the burden of meeting energy needs clearly falls most heavily on the poor households, who spend up to 20% of their income on energy carriers. Since the majority of households in the lower income groups are in Kazungula and SHHA, it is these areas that are spending significant proportions of their income on meeting their energy needs.

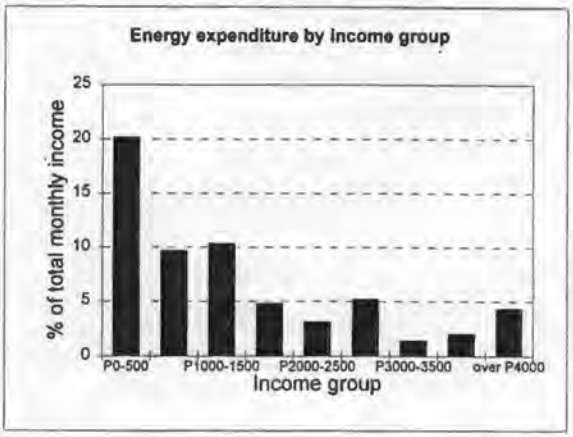


Figure 3.9: Household energy expenditure as a percentage of income

An analysis of the questionnaire data indicates that the minimum amount spent by low-income households on energy is about P25 per month. This may reflect the minimum energy requirements for households in the study area. A typical profile of fuels purchased for this amount per month is: P8 on paraffin (7.5 litres), P6 on candles (2.6 packets) and P10 on batteries. Wood is also used, but is often collected free of charge by such households. It is interesting that low-income households still spend significant amounts on batteries, which do not meet any basic energy need, and thus are more of a luxury item. The disposable income indicators given in table 2.8 also suggest that energy expenditure is, in general, not severely restricted by available disposable income. The proportion of income spent on energy by lower income groups is nevertheless high, and indicates that it may be a problem for them.

Expenditure on energy for electrified and non-electrified households

Although an analysis of energy expenditure for households with and without electricity in the same income group and area was attempted, no settlement with a reasonable sample of suitable households exists. The most credible analysis was for the SHHA area, where 6 electrified and 20 unelectrified houses in the same income group were compared. The former spent on average P 110 per month on energy goods, and the latter P 196. Although this analysis is based on a limited sample and should therefore be regarded with some caution, it provides further evidence that access to electricity reduces household energy expenditure.

Quantity of fuels used by households

Table 3.10 shows the differences in quantities of fuels used in different settlements by users of the energy source (i.e. not averaged over the entire sample), and compares the weighted total for all settlements with quantities found in the baseline study. It can be seen that quantities used are similar to those of 1987, except that more wood may have been used then[9]. The indications

[9] There is however some uncertainty concerning the weights of wood used in the baseline study, as the figures are given by volume, and the conversion to weight is not specified. The fuelwood weights derived from the baseline study may therefore not be accurate.

are therefore that household energy patterns have not changed dramatically over the last six years where fuels used are the same. This tells us that changes in energy expenditure on fuels is largely due to changes in population characteristics rather than shifts in use patterns.

Table 3.10: Quantities of fuels used by households (those using the fuel)

(quantity/hshld /month)	Kazungula	Plateau	SHHA	Govt	Pvt river-front	ALL AREAS	Baseline
paraffin (litres)	9	4	8	8	0	7	6
gas (kg)	13	9	19	14	15	15	19
candles (No.)	25	0	24	23	0	24	23
car batts (chrgs)	4	0	10	0	2	8	-
genset (litres)	0	0	140	0	0	140	?
wood (kg)	111	98	108	65	0	98	125

Appliances

Electrified areas utilise electric lights, radios or hi-fi, and about one third of electrified houses have a TV, iron and/or fridge. Hi-fis and radios are powered by batteries in unelectrified houses. Households using paraffin almost always have a paraffin light, and 38% of households using paraffin also have paraffin stoves. Those using gas almost always have a gas stove (this is supplied by the government for a number of state employees), while a few gas users also have gas fridges. It is noteworthy that electricity is generally not used for cooking in connected households, in spite of its greater convenience (gas bottles are considered by some to be inconvenient to replace). Table 3.11 shows that there is no cost advantage of using gas over electricity (it also shows the cost-effectiveness of using paraffin for cooking).

Table 3.11: The cost of cooking with different fuels

	Wood	Paraffin	Gas	Electricity
Cost	P 0.33 /kg**	P 1.07 /litre	P 2.60 /kg	P 0.27 /kWh
Energy content	17 MJ/kg	38 MJ/litre	49 MJ/kg	3.6 MJ/kWh
Cost of NETT energy	1.94 t/MJ	2.82 t/MJ	5.31 t/MJ	7.5 t/MJ
Efficiency of use*	15%	40%	45%	65%
Cost of USEFUL energy	12.9 t/MJ	7.1 t/MJ	11.8 t/MJ	11.5 t/MJ
Cost of cooking a meal (5.4 MJ)***	69.7 t	38.3 t	63.7 t	62.1 t

* - efficiencies based on the World Bank *Household Energy Handbook*
** - where wood is purchased
*** - energy requirement from Benett (1977)

A more detailed analysis of appliance purchase and use in electrified households showed that there is some correlation between the length of residence in an electrified house and the number of appliances - where residents have been in an electrified house for over 2 years, they own 7 appliances on average, while those who have been in an electrified house for a shorter period typically have 3 to 4 appliances. It should however, be noted that this trend is distorted because often state employees would have been transferred from one electrified house to another, and thus 'length of time in electrified house' does not reflect length of time from first having access to electricity (albeit not in Kasane).

The most common electric appliances were irons, fridges, fans, radios, and TVs. Kettles, videos, electrical insect repellants and hi-fis were less common, being used by 15 to 20% of households. In a few cases, wealthier households also had an airconditioner. The role of electricity in cooling was clearly important to many households (those without electricity have no access to cooling appliances).

The baseline study indicated that roughly the same proportion of households owned radios as was the case in this study (i.e. around 60%), while TV ownership increased from about 1% of households to 12%.

Family roles in the purchase and use of appliances

A study concerning the decision-making process in household electrical appliance purchase showed that women are often involved in the process, and often pay for them as well (a significant number of women are salaried employees - usually in government service - and are the main breadwinners in households). In general, there was no evidence of appliances purchased benefitting any particular members of the family only.

Wood use

The investigation shows that wood is still used extensively in the Kasane area. All households from the survey in Kazungula still use firewood, while in the SHHA, Plateau and Government areas a large proportion of households still use wood (table 3.12). The baseline study data indicated that 32% of wood users bought wood (it could not be ascertained what proportion of these also collected), while the current survey indicates that about 50% buy wood on occasions. Wood is abundant in the SHHA area, but is difficult to access as a result of game (elephants mostly) which threaten people when collecting. Many households therefore choose to buy wood instead, and this has resulted in a high relative expenditure on wood in relation to income for the SHHA households (see table 3.9). Except for the SHHA area, most of the households where wood is used for cooking still collect their own wood.

Table 3.12: Obtaining wood (households that use wood)

(% hsholds)	Kazungula	Plateau	SHHA	Govt	Pvt river-front	ALL AREAS
% hh using wood	100	32	88	32	0	40
only collect	53	78	23	88	0	48
buy & collect	34	22	44	13	0	29
only buy	13	0	33	0	0	22
collection hrs/mth	20	1	10	0.4	0	8

Where wood is collected, it is obviously a cost-effective cooking fuel, although it is the most expensive fuel in terms of useful energy (12.9 t/MJ) where it is purchased (table 3.11). In fact, if evaluated in this way it compares badly with paraffin (7.1 t/MJ) which is the cheapest fuel for cooking a meal.

A PRA exercise in Kazungula showed that nine different types of wood were highly rated as a source of domestic energy. These were Mopani, which is rated as the best, followed by Motswiri, Mokosi, Moswpeba, Moselesele and Motsensela. The remaining three were rated as similar - they were Mosheshe, Mosandi, Mogonono. Although Mopani was rated as the best, the wood which was most commonly used is from a species commonly known as Mokosi and Moswpeba. Mopani is naturally less abundant in the forests near the study area.

The information on the most popular as well as the most used wood types was augmented by in-depth interviews. It is clear that, as far as selection of species for use as firewood is concerned, households in different areas have similar preferences as well as similar use patterns.

Generally, wood is not seen as scarce in this well wooded area of Botswana. Some households (see figure 3.9) did consider wood as scarce, however. This perception of the scarcity of firewood is probably a reference of scarcity in the terms of safe localities where wood can be collected - as the biggest problem with the gathering of firewood is the threat of wild animals, including elephants and lions, which roam freely in the forests adjacent to these settlements. The distance travelled to collect the wood was considered a problem by some households. However, an investigation into the length of time it takes households to collect the wood indicates that wood cannot be far away. Woodgathering times varied from 20 hours per month to less than 1 hour per month (see table 3.12). In comparison to other areas in Southern Africa, the time which the study area's inhabitants spends on collection of wood is very small.

An outdoor cooking shelter (right) next to a house in the SHHA area. Many households use such shelters for woodfires.

Woodgathering is done by both men and women in the household. This departs from other areas in Africa where women are mainly responsible for gathering firewood. Some women commented that they were too scared of the elephants to collect firewood. Figure 2.16 gives a breakdown of family roles in wood collection.

There have been no systematic studies on firewood consumption and use patterns for this area. Members of the forestry department mentioned that they would be investigating firewood consumption and use patterns in the future.

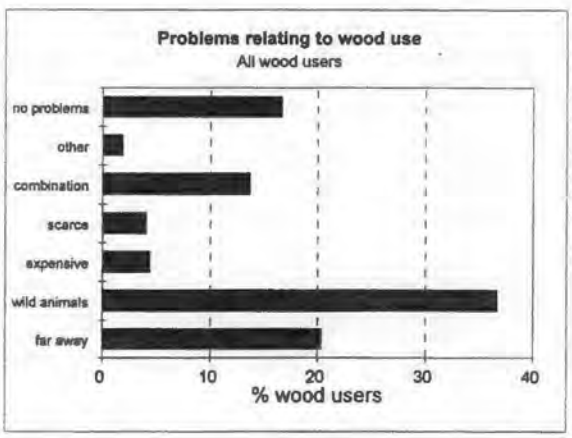


Figure 3.10: Problems relating to wood use - total sample

Health

While households did not raise it as a problem, staff at the hospital mentioned that paraffin poisoning was one of the most common accidents for which children were brought to hospital. The health implication of using paraffin indoors was also not commonly raised, but is a known contributor to respiratory illnesses. Wood is generally used outdoors only.

According to BPC, there have been no known incidents of electric shocks or other related accidents, and households also did not raise this as a problem.

Perceptions of electricity use

Perceived benefits & problems - electricity users

The great majority of connected households agreed that they have benefited by having access to electricity. Reasons given revolved mainly around the ability to utilise the great range of electrical appliances and improved quality of lighting, while 18% of users also considered it to be a cheaper energy source than using other fuels.

About one-third of electricity users said that they had experienced problems with the electricity supply. Power failures were the main problem mentioned, although it was also generally agreed that these have become increasingly infrequent over recent years. Power surges have apparently also occurred, and one or two households indicated that damage to appliances had resulted.

Most electricity users thought that they were spending less on energy than they would have if they were not connected, but about 30% thought they were now spending more.

Perceptions relating to electricity connection and use - unelectrified households

Over 80% of unelectrified households want electricity, and those saying that they did not were often lower income households who believed they could not afford it. The ability to use electrical appliances and improved lighting were the most common reasons given for wanting electricity.

Overall, electricity was considered very expensive to obtain. 81% of unelectrified households gave this as the reason for not connecting. 10% indicated that they intended to connect at some stage in the future, while 8% had not connected because they were renting the house and thus would not spend money on it. Nevertheless, expectations of electricity payments were realistic in most unelectrified houses, with the average connection cost 'considered fair' being P 683, and the average monthly payment 'considered fair' being P 67. The latter compares well with actual monthly bills of households, which typically range from P 50 to P 70, while the former is lower than the current connection fee of P 1135. It should be noted that in spite of the reasonably realistic perceptions of the cost, these payments were largely considered unaffordable.

Projected appliance purchases - households with and without electricity

Electricity users were asked to list appliances which they still wanted to purchase. The most popular appliance was a TV set (83% of households had this in their first two choices), with fridges and kettles also being high priorities. The interest in TV sets may have an element of wishful thinking, as there is no TV reception in Kasane at present, and thus they are useless without a video or a satellite dish.

Amongst unelectrified houses, high priority was given to obtaining fridges, stoves or hotplates, hi-fis or radios, and TVs - in order of preference. While lights were mentioned by fewer households as being a priority, it is likely that this is due to oversight rather than its relative unimportance.

3.4 COMMUNITY FACILITIES AND SOCIAL ASPECTS OF ENERGY USE

Schools and the education centre

Chobe Junior Secondary School (CJSS)

CJSS has been electrified since it was built on its current premises. The only sources of energy used are electricity and coal. Electricity is extensively used, as is illustrated in table 3.13, while coal is used for cooking in the kitchens.

Table 3.13: Electricity use in Chobe Junior Secondary School

Offices:	lights, typewriter, computers, fans, switchboard, photocopier, duplicating machines, and satellite TV
Classrooms:	lighting, overhead projector and domestic science appliances (iron, toaster, stove, coffee machine, sewing machine, fridge)
Kitchen:	freezers, extractor fans, fridge, urns
Hostel accommodation:	lights only
Woodwork class:	electric drill, table saw
Hall:	lights, TV & video, disco 'machine'
Whole area:	street lights are situated throughout the school grounds

Lights allow for night-time study classes, which are held every weekday evening, and the classrooms are also used by the department of non-formal education in the evenings. Videos are also used for educational purposes, and overhead projectors are used in classrooms. Recently, satellite TV reception has been acquired via donor assistance, and this may further help in the provision of a broader education. The administration office is also heavily dependent on electrical equipment, and the teachers accommodation is also supplied with electricity. Electricity is therefore important to the operation of the school, with the lights and TV potentially having amongst the most important impact on education.

Kasane and Kazungula Primary Schools

It is apparently not government policy to electrify primary schools. Teachers' accommodation at both the Kasane and Kazungula schools are electrified, although the latter were only connected early in 1994. Teachers at the Kazungula school considered it important that the staff houses were electrified as this allowed them to continue with lesson preparation at night, and made them more content with their work, but they also thought that classrooms should have access to electrical appliances. Videos and lights for night classes and during rainy days were mentioned as important.

The Hospital

The Kasane hospital is highly dependent on electricity for a number of purposes (table 3.14). The hospital used to run off two large diesel generators, and now has one as a backup to grid electricity (72kVA). Gas is used for cooking. Before it connected to the grid in 1987, the genset used to provide power for 12 to 14 hours during the day, and at night hurricane lamps were used for lighting.

Table 3.14: Electricity use in the Kasane hospital

Operating theatre:	lights suction machine
Wards:	lights fans - keep malaria patients cool & keep away mosquitoes
Baby care unit:	lights incubators
Laboratory:	microscope & other equipment
Mortuary:	cooling equipment
Pharmacy:	airconditioning fridges for medicines
Kitchen:	fridges & deep freezers
X-ray department:	X-ray equipment
Laundry:	washing machines dryers

It was difficult to determine the electric equipment used before grid power was connected, as no staff members who had been at the hospital from before 1987 could be located. Differences that could be ascertained related to the 24-hour availability of electricity, which allowed the use of electric lights at night, including in emergency cases, and the use of fans at night in the wards. It is also likely that the procurement of at least some of the other electrical equipment related to the availability of reliable 24-hour power.

Recreation

The availability of electricity has had an impact on recreation in the study area. The operation of bars and restaurants is facilitated due to electric lighting and refrigeration, and some also have video games. Although public video showings are also held in the SHHA area, those organising the shows need to provide their own generator, as the hall used has no electricity. There are plans to build a new hall on the Plateau, which will be connected to the grid.

The Cool Joint - a well known night spot in the SHHA area. Lights, drinks fridges and video games are all powered by electricity.

Street lights

The importance of street lights was raised by numerous respondent from all sectors. It is not only hoped to be an effective measure against crime, but will allow for easier movement at night, partly because of the abundance of game in the area (there is a story about a person having walked under an elephant's belly on a dark night).

In areas where streetlights exist, people feel safer, and are able to walk around more easily after dark. Plateau has street lights, and SHHA is in the process of having them installed. The commercial and industrial areas (which are largely unoccupied), also have streetlights, although in some areas they have been switched off due to the low occupancy level.

The Kazungula industrial sites - fully reticulated, and with streetlights, but not yet well utilised.

3.5 ENERGY USE BY BUSINESSES

In general, businesses in the study area are largely dependent on grid electricity for most of their energy needs, although gas is used for cooking in lodges and restaurants. Energy use patterns appear to have changed substantially from the time of the baseline study, when paraffin and candles were more widely used for lighting, and gas was used for refrigeration by a few businesses. Use of generators has also decreased markedly.

Tourist related businesses

The tourist industry is a major component of the areas economy, and is also the major user of electricity. It is an important consumer of gas, which is used in lodge kitchens for cooking. One lodge which is situated just outside of Kasane, Chilwero Lodge, only used grid electricity for water pumping. Other energy needs are met by solar power, paraffin, gas and wood. Not converting fully to electricity was a policy decision to maintain an 'African safari' type atmosphere.

In general, the tourist lodges connected to grid electricity relatively promptly, and kept the existing gensets as backups.

While the lodges are the major component of the tourist trade, other safari operator companies are also located in the area. They are also dependent on electricity to some extent, and they also use gas for their safaris. Their electricity consumption is much less than that of the lodges.

Energy costs before and after electricity

The three tourist lodges which existed in 1987 (Chilwero is excluded) all used generators, and therefore were largely geared for electricity use. Their total installed capacity was about 700kVA, and generators were typically run for 10 to 14 hours per day. No gensets were run continuously. The comparison between energy use characteristics before and after grid connection is given in table 3.15, and shows that the lodges are presently saving on electricity costs, in spite of the greatly increased kWh consumption. The cost per kWh from gensets is at least triple that from grid electricity.

Table 3.15: Electricity use and costs by tourist lodges before and after grid connection

LODGE	pre-grid connection (converted to '94 Pula)					1994 electricity use			
	genset kVA	kWh/ mth	fuel cost/ mth	other running costs /mth*	total cost/ mth	elec kWh/ mth	kWh charge/ mth	demand charge/ mth	total charge/ mth
Game Lodge	500	20000	P15000	P3000	18000	40000	P5600	P3600	P9200
Safari Lodge	140	11300	P4000	P800	4800	22000	P3200	P2200	P5400
Kubu Lodge	50**	3000	P1500	P300	1800	11200	P1600	P950	P2550
Chilwero Lodge	15**	900	P800	P160	960	21000*	P3000	-	P3000
TOTALS	705	**35200**	P21300	P4260	**25560**	**94200**	P13400	P6750	**P20150**

* - includes lubrication, maintenance, repairs and labour - taken as 20% of fuel costs

** - estimated

Note: much of this information was based on estimates given by persons interviewed, and therefore figures on genset consumption and costs in particular may not be consistent with other sections of the report.

In the past, wood was often used to heat up geysers for guest accommodation. All lodges now use electricity for water heating. The Game Lodge had solar water heaters, because the water heating requirements were beyond the supply capabilities of the diesel generators. These were also changed over to grid electricity, partly because the solar units required too much maintenance.

All lodges use gas for cooking, and gas bills for the larger lodges can be up to P2000 per month. As a rough indication, they are often about 20% of the electricity bill. In total, the tourist trade uses about 2500kg of gas per month (including the safari companies).

Use and benefits of electricity

The benefits of electricity for the tourist industry go beyond cost savings. The 24-hour availability of electricity has resulted in greater convenience for guests (lights, fans and airconditioners can be used at will), has made larger capacity cold rooms viable, and improves the availability of hot water. One Lodge mentioned that they needed two ice machines to make enough ice during the period that the generator was running, whereas now one machine is sufficient, as it can produce ice continually.

The greater capacity of the grid electricity supply has also allowed a lodge to convert from solar water heating systems to electric geysers. The manager considers that this reduced their maintenance burden.

Mowana Lodge, which is now the lodge with the greatest accommodation capacity, became operational in 1992. It is a modern hotel, and relies heavily on electricity for a great range of activities in the kitchen, laundry, office and in the guest accommodation, where each room is airconditioned. The decision to build the lodge was at least partly influenced by the availability

have been difficult to run without electricity. Because of the amount of electrical equipment in the lodge, a complex load management system was installed to minimise the peak load charges. The lodge also has a 250kVA backup generator.

The laundry at Mowana Lodge is heavily dependent on electricity. Electric industrial washing machines, tumble dryers and roller irons are used.

The main distribution board with load management unit (box on left) at Mowana Lodge. The 250kVA backup genset can also be seen.

Some of the lodges and safari operators also have well equipped workshops which utilise electricity extensively. One safari operator only had a single-phase genset supply previously, but can now utilise 3-phase workshop equipment.

The functioning of offices has also been facilitated by the continuous availability of electricity due to the improved ability to use a range of office equipment at all hours, particularly since lodge reception offices often are open for extended hours.

Table 3.16: Electrical equipment used in tourist lodges and safari operators

Offices lights faxes typewriters computers & printers switchboards photocopiers fan airconditioning alarm systems	**Accommodation** lights fan airconditioning geysers music power points	**Laundry** lights washing machines dryers irons roller irons
Grounds lights security lights water pumps fire pumps pool pumps sewerage pumps	**Workshops** lights welders drills compressors grinders saws battery chargers steam cleaners	**Kitchens** lights kettles or urns fridges deep freezers walk-in freezers cold rooms ice machines 'hot-display' heaters extractor fans toasters warmers microwaves

In view of the high crime rate in the area, particularly along the river front where the majority of lodges and one large safari operator is situated, security lighting is an important application for electricity. The continuous availability of grid power obviously facilitates the use of such lighting, as with gensets it would have been much more expensive and awkward to run them right through the night.

Operating and maintaining generators is widely considered inconvenient. Also, spares are not readily available in Kasane, and therefore breakdowns can result in extended power cuts or reduced generating capacity. Most lodges have kept at least some of their original generating capacity as a backup, partly motivated by the initial unreliability of the grid supply. There is presently about 750kVA of backup generator capacity amongst the four tourist lodges (Mowana Lodge added 250kVA to the backup capacity when it was built in 1992, thus there is more backup capacity now than there was primary generating capacity before grid power was available). While the backup sets must still be maintained, the service frequency is greatly reduced. One lodge mentioned that they now service sets every year, as opposed to every month when the gensets were the main source of electricity.

In spite of the greater convenience of having grid electricity, particularly for guests, there were no clear indications that the volume of guests had changed in any way as a result of the introduction of electricity.

Electrification of staff premises

While most of the lodges provide some accommodation for staff, these are not always electrified. Where they are electrified, staff have access to fridges, lights and hot water.

Problems experienced

Although the benefits of electricity for the tourist businesses are clearly extensive, the majority of businesses interviewed raised problems concerning the supply. Electricity was generally considered very expensive, and a number of lodges thought that gensets would be cheaper. Some were considering using their gensets for a proportion of the time in an attempt to reduce their payments - particularly their peak demand charges. Two lodges who were on the 'Business 2' tariff were particularly unhappy with the demand portion of their electricity bill. Both of these businesses have extremely seasonal loads which correspond to the tourist season, and thus they use significantly less energy for three to six months of the year - in fact, one place actually closes down for a few months and so uses no electricity at all. Because the demand charge is based on *'the actual demand for the month or 90% of the peak demand over the last 12 months, whichever is the greater'*, these businesses pay a significant demand charge all year round, and they consider this unfair. Part of the motivation for the complex load management system at Mowana Lodge is also because of the high demand charge.

One lodge is not a heavy consumer of electricity, and has a peak demand of below 35kW for a significant part of the year, if not all year. Nevertheless, the owner was advised by BPC to install a power supply capacity of over 35kW to accommodate possible expansion, and therefore was liable for a demand charge tariff (Business 2). The owner feels that if she had known what the cost implications were, she would rather have opted for a lower capacity supply and lived with any resulting limitations. Although she feels a strong need for security lights to discourage crime at her lodge, she presently cannot afford the increased electricity payments which would result.

Connection costs were also considered high by businesses, who often had to pay for grid extension and a transformer on top of the connection costs. In some cases, the premises also needed to be rewired before a supply was connected.

It is interesting that two perceptions encountered reflect a lack of knowledge concerning the relative costs of different electricity tariffs, or of electricity costs relative to genset power costs. In the former case, where the demand charge was considered to increase their electricity costs significantly, an analysis shows that almost all of the 'Business 2' consumers are in fact paying 10 to 20% less than they would be on a 'Business 1' tariff, which has no demand charge but a higher energy charge. The perception that diesel generated power is cheaper than grid electricity is also erroneous - some businesses may be paying more per month, but it is because they are using significantly more electricity than they were from a genset. It is unlikely that genset costs would ever be near grid costs, even in the case of a very low load factor grid electricity consumption pattern (and thus relatively high demand charge component).

These perceptions nevertheless illustrate a certain ignorance concerning electricity use in general, and this is at least partly a result of their being no BPC customer oriented information or marketing service in Kasane. Also, it was clear that very few customers understood their electricity bills, which again points to a lack of communication between the utility and their customers.

Tourist businesses generally agreed that whereas BPC had at one stage been inefficient, they were now operating satisfactorily. Power cut frequency had also reduced significantly from the early years of grid connection, and now are not considered an inconvenience.

A final problem mentioned by a few businesses in the tourist trade related to the quality of the power supply. Power spikes are known to occur, and as a result protection has to be installed on sensitive equipment, incurring expense which would have been avoided if the supply quality was more consistent. At least one business damaged some computer equipment due to the spikes.

Wholesalers & distributors[10]

While the wholesaler and distribution businesses play a significant role in the economy of the area, they are in general not major users of electricity, and no other energy carriers are used. Many of these business utilise electricity for important appliances such as tills, fax machines and security lights, and therefore are dependent on it to a large extent. Security lights in particular would be very difficult to run off another electricity source.

The largest electricity consumer in the 'Wholesale & distributor' category is the major wholesaler Sefalana, who is charged at the 'Business 2' tariff. The reason for the higher consumption is because of the use of freezers and fridges, and also a significant amount of security lighting.

Many of these businesses have the usual set of office equipment (faxes, photocopiers, typewriters, computers, fans, and airconditioning), and security lights are essential to most.

Almost all of these businesses regarded electricity as a minor expense, and an important part of their operation. A drinks wholesaler in Kazungula was the exception, and the owner did not feel that the business was particularly dependent on electricity, in spite of using fans, water coolers, a kettle and security lights, and plans to purchase a computer.

Retailers

Energy use by retailers

Retailers have almost all connected to electricity, although some waited a number of years before connecting. The one retailer encountered that did not connect was a few hundred meters from an electricity line, and was planning to move premises. Before grid electricity was available, many of the larger shops used generators, usually for refrigeration. Some also powered microwaves, tills and fans. Gas was used for refrigeration in a few cases, and is still used for cooking in the restaurants which are associated with some of the larger general dealers.

Major uses of grid electricity

The most important areas where grid electricity has impacted on the operation of retailers are those relating to refrigeration capacity and the ability to utilise appliances such as baking ovens. While the old generators limited the power consumption of shops, and therefore their refrigeration capacity, with the availability of grid power a number of shops have expanded (even doubled) their refrigeration capacity. In one shop, refrigerated goods account for 33% of the total turnover - in this case the owner would not have established the shop were it not for grid electricity. The butchery in Kasane is also heavily reliant on electricity for refrigeration.

Many retailers also have the usual set of electrical office appliances (fax, computer, fans, airconditioning etc), and one has a photographic processing machine. Tills are also widely used by shops, and lights are particularly important in 'night spots' such as bars and restaurants. These often also have game machines. Security lights are also often used by retailers.

One general dealer and restaurant has an electric baking oven, which they say has attracted a greater volume of customers, as bread is baked only in a few locations around the study area. Previously, they used to fetch 20 dozen loaves of bread from Francistown or Zimbabwe every week, now they bake 10 dozen loaves per day. The owners consider the bread oven and greater refrigeration capacity to have increased the profitability of the business. They have also employed 4 extra people to work in the bakery.

[10] In the Kasane/Kazungula area, this category includes wholesalers, a large building materials and gas supplier, and an import/export warehouse.

Impact of electricity on sales on other energy carriers

Many general dealers sell candles and batteries. Although electricity availability in the area could potentially reduce the sales of these goods and thus affect turnover, this has not happened, largely because the majority of households cannot afford to connect. In any case, sales of energy carriers are usually not central to shop business.

Cost of electricity

Many shops did not consider electricity to be too expensive, although it was usually not regarded as an insignificant expense. In a few cases, grid electricity expenditure was said to be much the same as what used to be spent on generator electricity, although the service provided by grid power was considered to be far superior.

Problems experienced

Currently, power failures are not considered to be excessively frequent (although one retailer has solar powered calculators to replace the tills when the power is off). A more significant problem which arose related to the quality of the electrical supply. A number of businesses mentioned that they had experienced damage to sensitive equipment such as scales and tills due to power surges, and it was common practice to protect computers from these surges by using UPS units (Uninterruptible Power Supply). Such units can be expensive.

Transport related business

Transport related businesses include petrol stations and auto workshops of which there are two of each in the study area. All use electricity - the petrol stations for pumping, and the workshops for a range of equipment such as welders, compressors, grinders, and drills. As with most businesses, security lights are important. Office appliances and tills are also used. These businesses are therefore dependent on electricity to a large degree.

The garage and workshop (behind to the left) at 4-Ways in Kazungula. The workshop uses a welder, compressor and a grinder. Security lights and petrol pumps also use electricity.

Other businesses

Other businesses not included in the above categories include an 'office services' business, the local banking agency, a car rental office and a hair salon. These businesses generally rely on a range of electrical office appliances including computers, faxes, switchboards, photocopiers and typewriters. Security lights and alarm systems are also used, and require continuous electrical power.

While one business utilised generator electricity before connecting to the grid, the latter allowed the expansion of business scope to include ice-making. The hair salon is particularly dependent on electrical appliances, and uses hair dryers, clippers and lights.

As with other businesses, where computers are installed they require a UPS, largely because of potential damage via power spikes.

The local bank - they use a range of electric office equipment, computers, and security devices such as electric doors and time-lock safes.

Small businesses

While some small businesses have access to electricity, often via a generator or because they work from an electrified home, most do not. Some examples of the potential role of electricity in the operation of these businesses are discussed in the sections below.

Baking

There are three small bakeries operating in the area, none of which use electricity. One bakery owner/operator collects wood or hires others to collect it for the oven. She produces about 35 to 40 loaves of bread in a work day, and also some scones (compare this to the electric oven discussed earlier, where about 120 loaves per day are produced). The owner has to work hard to run her business, collecting and chopping wood, baking and selling bread. She spends about P 100 per month on wood - this would buy her about 370kWh of grid electricity, which would probably not be sufficient to run an electric baking oven. She feels that electricity is not important for her business, as it is functioning adequately as-is.

An electric bakery in the SHHA area - about 120 loaves of bread per day are produced.

A wood-oven bakery in the SHHA area - the owner operates the business alone, and produces about 35 to 40 loaves of bread per day.

Sewing & knitting

At least eight small sewing and/or knitting businesses operate in the study area. One operates in an electrified house, another two have generators, and the remainder use hand machines. All five businesses interviewed agreed that electric machines are much more productive than manual ones, and estimates of increases in output varied from 50 to 100%. It appears that a market for goods exists, and so the main limitation in business turnover relates to output. The implication is that electricity could benefit these businesses.

The sewing businesses that used generators considered them to be expensive, unreliable, and inconvenient. Breakdowns were frequent, and it was difficult to have them repaired locally. When they were repaired, the quality of repairs was also sometimes poor. One business

owner/operator remarked that she could not enter into contracts with schools or other organisations because of the unreliability of the generators. In contrast, the sewing business operating from an electrified house was supplying school uniforms, and also made nappies and pillow cases for the hospital.

One sewing group was spending P 350 per month on running the generator (excluding maintenance and repairs). For this amount of money, over 1000kWh of grid power could be purchased at current tariffs, which would easily be adequate to power their machines. The generator also had other disadvantages in this case - not all sewing machines could be used at once due to the capacity limit of the genset, and it was also mentioned that neighbours complained about the noise level of the generator.

Access to grid electricity would therefore benefit this type of business greatly, increasing productivity and probably reducing operating costs. While electricity is widely sought after, the connection fee has excluded most of these businesses from using it. In addition, its benefit would be enhanced by the ability of the business to access equipment financing from the Financial Aid Programme, as appliance costs are often a major constraint on small business use of electricity.

Carpentry

One small carpentry business is operating in the area and is located at the Kazungula industrial plots. It employs 7 people in total. A generator is used (costing about P 280 per month for petrol), even though the site is in a reticulated area. The high connection cost (over P 3000 for a 3-phase connection), and a lack of knowledge concerning the connection procedure are factors which have delayed the connection of the business.

Amongst the electrical tools already existing in the business are a compressor, sanding machines, planing machines, electric saws, grinders, a welder and drills. Generally, only one appliance can be used at a time due to the capacity limits on the generator. Also, the frequency of generator breakdowns are considered a problem.

A grid electricity supply is therefore likely to improve the productivity of this business, although at present other major problems are a higher priority - such as a reduced market due to their location far from their usual clientele in Kasane.

The carpentry business in Kazungula industrial area - a genset provides the electricity, but can usually only power one appliance at a time.

Informal business

Although about 30% of all households are involved in some form of small business, energy requirements for these businesses are not significant. Beer making, selling food and operating a small shop are the most common businesses. The demand for electricity in these businesses is not great due to the nature of their operation. Less than 5% use electricity. Those that do, were operating from houses in the electrified areas where they were running lights and fridges in small shops, or baking food.

The impact on these businesses in general has therefore been small, although wider access to electricity is likely to result in more utilisation of this energy source and thus increased benefit. However, this is probably not one of the areas where electricity will have a major impact either on household welfare or on the economy in general.

Business establishment or growth due to grid electricity availability

A number of businesses were encountered which would not have been established in the area were it not for the availability of grid electricity. Others would have been established as smaller concerns, or would not have expanded to the same extent. Table 3.17 indicates the extent to which the businesses in the area would have been different without the grid supply.

Table 3.17: Business establishment or growth in the area due to electricity

Would not have been established	Unlikely to have been established	Would have been smaller/ not expanded to the same extent
large supermarket hair salon furniture/appliance supplier elec. appliance shop electrical repair shop video hire shop office equipment business	butchery truck repair depot clothing store shoe shop	Mowana Lodge Sefalana wholesaler large general dealer restaurant/bakery bar/restaurant another bar

Inside the electrical appliance shop. This business would obviously not have been established here if the area was not connected to electricity.

It is estimated that, because of the establishment or growth of businesses due to the availability of grid electricity, between 70 to 100 jobs have been created (an increase of about 10%), and the private sector turnover in the area has increased by P 500 000 to P 650 000 per year (also about 10% increase). One of the most important factors in the growth of businesses was the release from power demand limits imposed by generator capacities, allowing increased refrigeration capacity and use of baking ovens, for example.

Also, some shops began selling electrical appliances, and one shop was established to cater specifically for this market. One of the largest businesses (and one of the largest employers) in the area, Mowana Lodge, would probably have been smaller were it not for the availability of grid power.

A significant number of businesses were also encountered which had expansion plans, many of which were reliant on grid electricity. One retailer was in the process of moving to larger premises in an electrified commercial area, and would not have undertaken this expansion were it not for the availability of grid power. A number of other businesses were also at various stages of being established or planned, some of which were also reliant on the existing electricity supply (see section on 'Development priorities, constraints and plans').

3.6 ENERGY USE IN THE GOVERNMENT SECTOR

Energy sources

The government is a significant user of electricity, accounting for 21% of the total electricity consumption in the area, and having about 10 high demand (i.e. over 35 kW) consumers. Electricity is extensively used by almost all government departments, many of which now rely on electricity to a high degree. In total, four government departments were encountered which did not have electricity - CTO (Central Transport Organisation), Department of Justice, Meteorology, and the Livestock & Veterinary office. The latter is in temporary premises and therefore has not connected, but the other offices are awaiting approval of funds to connect. All of these except the Justice office were in the area from before 1987.

Although government offices are largely reliant on electricity, a few other energy sources are used. Instances where this was the case include the prisons, who use wood for cooking in their kitchens (although they intend to convert the kitchen to electricity), and a few of the workshops in the area who use gas for welding.

Electricity use

Note: In most cases, state officials interviewed had not been in the area before electrification, and thus they were unable to compare the 'before' and 'after' operation of their departments. Impacts were therefore often evaluated by examining electrical equipment in the departments and assessing the extent to which current operations depend on this equipment.

Central Administration and other offices

Electricity has become an integral part of the operation of most offices, and is indispensable in a significant number. Some typical office equipment is listed in table 3.18.

Table 3.18: Typical electrical office equipment used by government departments

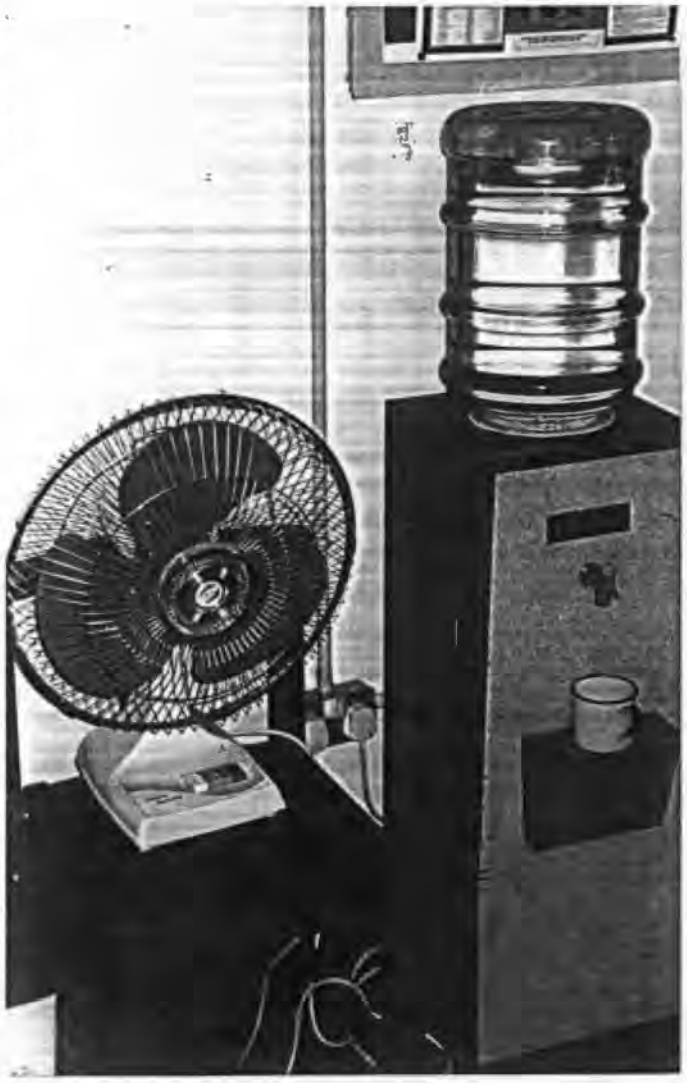
Standard office equipment	Common office equipment	Other offices equipment
lights	computer	adding machine
fax machine	printer	fridge
photocopier	airconditioning	light table
fan	typewriter	digital planimeter
water cooler	kettle	telex
	switchboard	

Many office staff members interviewed considered electricity to be an essential part of their efficient functioning. Before electricity, offices either had to go without equipment such as fax machines and photocopiers, or utilise the services of a local business (Kasane Enterprises), which

used generator power to run their fax and photocopier. There were apparently often queues to use this service.

Lights were also considered important. In the rainy season they were necessary during the day, and also allowed people to work late.

Another important benefit of electricity is through the use of cooling appliances. Offices usually have fans and access to a water cooler. Some offices are also airconditioned. These appliances are used continually. In contrast, the offices visited where there was no electricity regularly became uncomfortably hot. In the CTO office, staff members tried to schedule their day so that they finished with desk-work before it became too hot, and thereafter busied themselves with tasks outside the office.



Cooling appliances are a very important application for electricity - offices can otherwise become very uncomfortable.

A few offices used solar electricity before the advent of electricity, mainly to power 2-way radios (e.g. Information and Broadcasting) or to provide basic lighting (e.g. Forestry). Generators were generally not used to supply offices.

The benefits of electricity availability in offices has affected a great range of government departments, from Police through to the BDF and administration offices. The benefits to these offices probably constitute the most significant impact of electricity on the government.

Use and cost of generators

There were between 7 to 10 generators being used by the government before 1987. These were used mainly for important services such as security lighting (BDF and Prisons), communications (Police), water pumping (Water Affairs), workshop equipment (Brigades and BDF), and for petrol pumps (CTO). The remainder of the departments had no access to electricity. The total installed capacity was about 200 kVA.

The gensets were run from between 8 to 14 hours per day, depending on the application. Approximately 9000 kWh per month are thus estimated to have been generated from these sets[11] (compared with the current grid consumption of about 54000 kWh/month). This is estimated

[11] Assuming a 20% capacity factor and 90% power factor

to have cost P 100 000 to P 120 000[12] per year in operation and maintenance costs (excluding set replacements and capital costs)[13], or about P 1.00/kWh (compared with the current electricity tariff of P 0.34/kWh).

At present, there are 12 generators run by the state in the study area, most of which are used for backup purposes. Generators are still the main power source for the BDF camps at Sidudu, the Meteorological office, and the CTO (where petrol pumps are used). The total installed backup capacity is about 370 kVA, and that used as a main power source about 50 kVA[14]. It is estimated that approximately 1500 to 2000 kWh per month are currently generated from the latter. The backup sets are run only occasionally for maintenance purposes, not to generate power, and therefore only incur maintenance costs. The 'main power source' generators are estimated to cost the government about P 20 000 per year (P 1.00/kWh), and the maintenance costs on the backup sets about P 4000 per year[15].

The above estimates indicate that running generators is expensive relative to grid electricity costs, and departments which still use them for their principle power source have high energy costs. It may well be worthwhile for these departments to be connected to grid electricity as soon as possible. While this involves some capital outlay, a saving of about P 7000 per year can be expected on the running costs of a typical 30 kVA set.

Water pumping

One of the areas where electricity supply has benefitted the government and the area in general, is in the provision of water. The Department of Water Affairs, which is responsible for water provision, use electric pumps extensively. This department only connected a few years after electricity became available in the region, at the same time as a major upgrading of the capacity of the water processing and pumping plant. The main pumps used are shown in table 3.19, together with the diesel pumps used before electricity was connected.

Table 3.19 Pumping capacity and costs at the water processing plant - pre- and post-electrification.

1994	pre-electrification
3x6kW raw water pumps (pump from river to processing plant)	1x12.3kW & 1x21.6kW raw water pumps
3x30kW first stage-pumps (pump from processing plant up to Plateau ground-level tank)	1x21.6kW first-stage pump (with another as backup)
2x7.5kW second-stage pumps (pump from Plateau ground-level tank to raised tank)	(no elevated tank on the Plateau existed at this time)
Various other smaller pumps exist within the processing plant	
Total pumping capacity: 180kW	**Total used pumping capacity: 55kW**
Energy use estimate: 15 300 kWh/month	Energy use estimate: 10 000 kWh/month
Approximate monthly cost: P5 200 (P0.34/kWh tariff)	**Approximate monthly cost ('94 Pula): P6 000** (P0.60/kWh assumed for water pumping - including maintenance)

[12] In '94 Pula.

[13] Assuming 0.9 litres per kWh (at 20% capacity factor) and maintenance costs of 5% of the set capital costs per year.

[14] This is an estimate, because the capacity of the BDF sets at Sidudu are unknown.

[15] A cost of P 500 per set per year has been assumed.

Table 3.19 illustrates the lower operating costs of electricity, in spite of the greatly improved supply capacity.

Electricity is considered much more convenient and reliable for water pumping than the old diesel sets. In addition, electricity facilitates the operation of the processing plant laboratory, where a number of sensitive testing instruments require electrical power. Without electricity, it is questionable whether a plant of this capacity would have been feasible.

The benefits of electricity for water provision are therefore in cost savings, capacity improvements and convenience.

The three 30kW first-stage electric water pumps at the water processing plant.

The old 21.6kW diesel gensets which were used for pumping before electricity was connected.

Security

Security lighting is important for the BDF, police, prisons and border posts, and many other government departments also have security lighting to discourage theft. While some of these used generators to power security lights before the area was electrified, the availability of electricity facilitated the installation of lights at others, partly because of the 24-hour availability of grid electricity. The Kasane police station used to run a generator during the day to power the radio, and had no power at night (and thus only limited communications and no lights). With the advent of electricity they have constant power to radios and security lights.

Workshops

A number of workshops exist in the area. The Brigades, DEMS, BDF, Water Affairs and the CTO all have workshops (although the latter has no electricity). The prison is currently establishing a workshop. Electricity is essential to the operation of workshops. The following equipment is used by various departments: welders, drills, compressors, grinders, lathes, saws, planes, battery chargers and wheel balancers. Again, some of these workshops used generators previously, but this was considered to be expensive, inconvenient, unreliable and often the equipment that could be used was limited due to capacity limits on the gensets.

The CTO workshop has no access to electricity, even from a generator, and the impression gained was that they were incapacitated as a result. To perform even simple operations such as drilling or welding, they have to travel to an electrified workshop in Kasane. In addition, they use a petrol generator to power the petrol pumps which supply government vehicles. The generator is not only expensive and inconvenient to operate, but breakdowns are relatively common - rendering the fuel pumps useless and affecting the operation on the entire fleet of state vehicles. CTO have in fact just purchased a new petrol generator (the other two are considered irreparable) for roughly the same cost as the grid electricity connection fee (although they would still need to pay for the internal reticulation).

Communications

The establishment of the Botswana Telecomms Corporation operations centre in Kasane is also partly as a result of the availability of electricity. The centre houses complex electronic and other equipment, and also relies on airconditioners to keep temperatures within a certain range. They are also amongst the highest 10 electricity consumers in the area. While electricity is the principle power source, the power supply system is complex, with three or four backup levels. If the power fails, the backup battery bank comes on line. If this runs dry, the standby generator comes on-line, and finally, a bank of capacitors can keep the exchange powered for a further 24 hours. A microwave tower at Kazungula, which is an integral part of the communications system, has grid electricity, diesel and battery backup, and also has solar power (for unknown reasons).

If such an operation was to use diesel power, two diesel sets would be necessary at both the Kasane and Kazungula stations, one of which would need to be running continuously. The increased costs would be significant, and would probably triple the current electricity bill (about P 4000 p.m.). It is also likely that the operations centre would have been smaller if grid power was not available.

The improved communication in the area as a result of the operations centre establishment has had an impact on all sectors in the area by increasing the available telephone lines, and improving the service reliability. A few businesses mentioned that communications were central to their operation.

Other applications for electricity

In addition to the uses of grid electricity discussed above, there are numerous other applications for electricity in the area. Some examples are its use in the control tower at the airport, and to power water pumps for fire-fighting at the airport as well as at other government departments.

The government Supplies Depot - their modern offices and workshops rely on electricity. Security lights are also important.

Problems experienced with electricity

In general, no problems concerning the electricity supply were mentioned, although a member of the Prisons Department thought it unwise to be dependent on power from a foreign country. Usually, adequate notice of power cuts was given, and thus departments could adjust their operations accordingly. Power cuts were not regarded as excessively frequent.

3.7 ENERGY USE IN AGRICULTURE

Chobe Farms is the only significant user of any energy carriers, and is the only agricultural operation using grid electricity. Other commercial farms include a small poultry farm, which uses no energy carriers, and a crocodile farm which uses a genset to a small extent and gas for domestic purposes. Other agricultural activities mainly revolve around subsistence-type farming, in which energy carriers play no part other than powering tractors for ploughing in some cases.

The very low utilisation of electricity for agricultural activities is not unexpected, both because of the nature of the majority of agricultural operations, and from indications given by the baseline study that it was not a high priority amongst farmers.

Chobe Farms

Before connecting to electricity, Chobe Farms had a 10kVA diesel genset supplying the farm workshop and two houses, and a 120kW diesel pump down at the river. Now they are connected to two grid supply points - one for pumping, which is metered at the 'Business 2' tariff as the peak demand is over 35kW, and one which supplies the farm houses and other farm equipment, which is charged on the 'Business 1' tariff. The total cost of both supply points is about P 6000 per month. The farm connected to electricity in '87/88, and before connecting, undertook a financial study on the feasibility of doing so. The results came out marginally in favour of electricity, and so they decided to connect. Electricity is now used for all the loads which the diesel genset was supplying, and three 30kW electric pumps at the river have replaced the diesel pump. The electrically powered equipment currently in use is shown in table 3.20.

Table 3.20: Electricity use by Chobe Farms

Water pumping:	3x30kW pumps
Workshop:	compressor, welder, grinder
Office:	fans, fax machine
Staff houses:	3 staff houses connected
Cold storage:	3 cold/ripening rooms
Packing house:	fruit grading tables

Because three smaller pumps have replaced one large diesel pump, the irrigation pressure can be varied, which allows for drip irrigation, and gives some flexibility for when smaller amounts of water are required, such as for domestic purposes.

Another benefit of grid connection is the installation of the cold rooms, which was decided upon partly because of the availability of a continuous and relatively reliable power supply. These rooms allow produce to be harvested at will, stored until a market is found, and then ripened in the ripening room in time for transporting to the market. Previously, fruit was only harvested when markets were located in order to prevent wastage, which was less efficient than the current system of utilising the coldrooms.

The cold rooms at Chobe Farms. These would probably not have been installed if grid electricity was not available.

The diesel gensets were also considered demanding, requiring attention every day to start, monitor and maintain. The 10kVA set was also not run continuously, and thus electricity was only available part of the time.

Only three of the 11 staff houses are electrified. To connect the remainder is considered too expensive, and may be undertaken at some time in the future (it would probably not be very costly to do this since the low voltage network is already on the farm).

The 30kW electric water pumps used by Chobe Farms. Three of these replaced a 120kW diesel pump, giving greater flexibility in varying the water pressure for drip irrigation. They are also much more convenient to operate, although they are thought to be more expensive than the diesel pump.

The workshop at Chobe Farms - it was powered by a 10kVA genset before electricity connection.

While the operation of Chobe Farms is dependent on electricity to a significant degree, and grid electricity has brought certain benefits to the farm, the staff also have reservations regarding the supply. The farm appears to be only marginally profitable at present, partly to do with the difficulty of finding suitable markets and transporting produce from Kasane, and it therefore operates on a tight budget. Electricity is considered to be very expensive, to the extent that the staff are considering re-examining the viability of diesel power. There is also some unhappiness with the operation of BPC, who are considered by one staff member to be inefficient and to give unreliable quotes.

The small poultry farm

The poultry farm is not connected to grid electricity, in spite of being close to the MV/LV transformer of Chobe Farms. A few years ago, they purchased a small solar electricity system with a view to using it for lighting in the chicken run (they have about 200 chickens). They expected the additional light to improve the egg laying. The system never worked due to bad design and poor installation.

They indicated that they could probably afford the likely connection costs, but believed electricity from the grid to be more expensive than that from a genset. This is unlikely considering their proximity to a transformer and the capital and running costs of a genset. It is noteworthy that they know little about the costs and benefits of electricity, although the need for electric lighting clearly exists. They also happen to be situated closer to the BPC depot than any other potential consumer.

The chicken run at the poultry farm. The BPC depot and transformer is in the background (back left). An MV line pole can also be seen on the right.

The crocodile farm

The crocodile farm has not connected to grid electricity partly due the connection cost required. Their energy requirements are in any case small, and the generator and gas supply is entirely for domestic purposes. If the market for crocodile products improves, cold rooms which have been constructed may be utilised, in which case the energy needs of the farm will increase.

Other small farms

As has been mentioned, small farms in the area are mainly subsistence operations, and use no energy carriers except for diesel where tractors are used for ploughing. Electricity is not used at all, although it could potentially benefit small farmers significantly by facilitating water pumping, as lack of irrigation is one of their major problems.

CHAPTER 4

IMPACTS OF ELECTRICITY

CHAPTER 4

IMPACTS OF ELECTRICITY

4.1 ECONOMIC IMPACTS

Business sector

Tourist industry

Some benefits which were considered amongst the most important for the tourist lodges were the greater convenience experienced by guests with 24-hour availability of lighting, fans and water heating, the increased ability to cool - in guest accommodation, in food storage rooms and in ice machines, and the ability to run security lights throughout the night. The range of appliances used by lodges and safari operators has also increased. In general, appliance use was restricted with generators because of their capacity limitations. The greater convenience of electricity for maintenance staff compared with operating and maintaining a genset was also frequently mentioned as an important benefit. Repairs were often particularly problematic due to the difficulty in obtaining spares. Grid connection also appears to have reduced their electricity costs, in spite of the higher energy consumption.

Wholesalers, distributors and retailers

Retailers are amongst those businesses that have benefitted most from the availability of grid electricity. This has allowed for increased refrigeration, and in one instance, a baking oven to be installed. The impact on the turnover of these business is significant. Most retailers and wholesalers also have a range of office equipment, and security lights are commonly used.

Transport related industry

These businesses utilise electricity mainly for workshop equipment, office appliances and security lighting. The use of appliances with genset electricity is likely to have been more limited, and costs would have been higher.

Small and informal businesses

Very few small or informal businesses have access to grid electricity. It is, however, apparent that grid connection could benefit some of them significantly. Sewing groups in particular, are either forced to use slow hand machines or tolerate the problems associated with running a generator. A local carpenter shop also relies on a generator, and grid connection is likely improve the productivity of this business.

A petrol generator used by a sewing group in the SHHA area. They consider the generator to be inconvenient, unreliable, noisy and expensive.

Problems experienced with electricity

Several businesses raised some noteworthy complaints concerning the electricity supply. For the tourist industry, the most important of these relate to the high demand charges, which are particularly harsh on seasonal businesses, and the quality of the electricity supply, which necessitates often expensive protection of sensitive electronic equipment and fridges. The latter point also applies to many other businesses such as retailers and offices.

It was also apparent that customers did not understand their electricity bills, and that many erroneously believed that gensets could save them money on existing electricity payments. Billing was also sometimes considered inefficient. There is thus scope for improved customer services from BPC at Kasane.

Businesses often felt that electricity should have played a greater role in the security of the area. It was felt that streetlights and the use of security lights (which are currently considered very expensive to run) at businesses would ameliorate the situation, but these measures had not yet been addressed in spite of their importance to the business community and the settlements in general.

Smaller businesses usually found the electricity connection cost unaffordable, and therefore were effectively excluded from the benefits of electricity.

Comparison between actual impacts and those expected from the baseline study

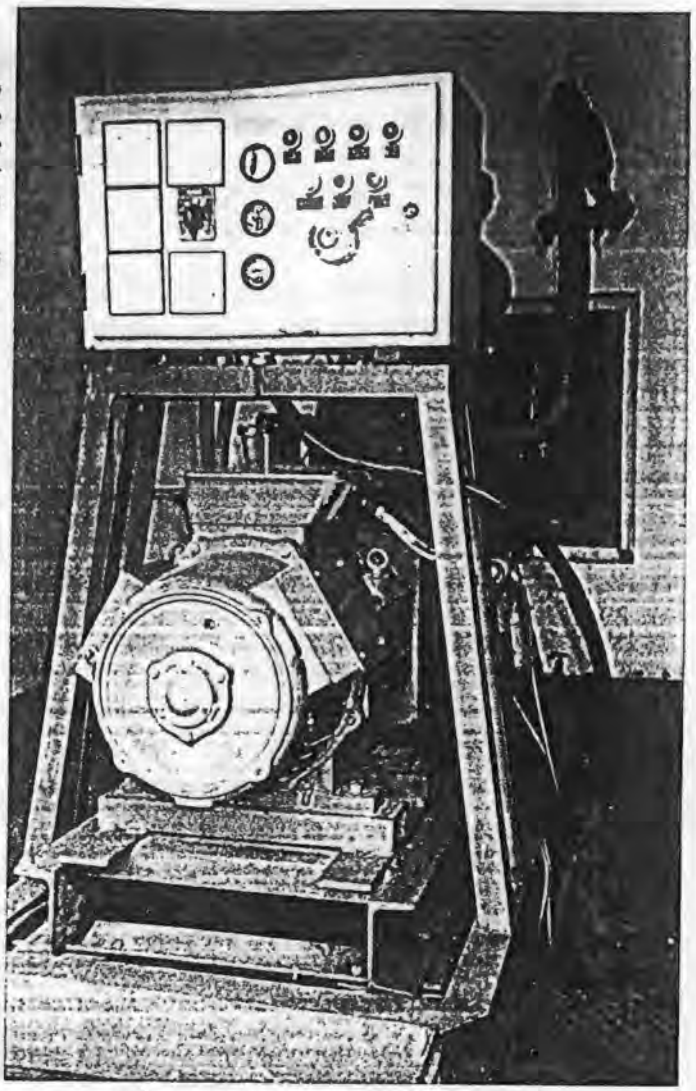
The baseline study found that 24% of businesses intended to connect to grid electricity (more details of business type are unknown), while 74% were unsure. The benefits of electricity were also unclear to many businesses, and there appears to have been a certain reluctance to pay realistic amounts for the connection as a result. The rate at which businesses connected initially reflects this uncertainty, but over time the majority of larger businesses have connected. Larger (and richer) business ('Business 2' consumers) connected more rapidly, as was expected from the baseline study.

Government

The impact of electricity on state departments has been significant. Not only has electricity replaced gensets, which are expensive, inconvenient, unreliable and often limiting in terms of hours of use and peak power output, but the numerous departments which were previously without electricity now have access to electrical appliances.

Major areas of benefit include the efficiency of operation in offices and the improved working conditions, largely due to adequate lighting and the use of cooling appliances. It is likely that this has made a significant difference to the effective operation of government in general. The electrification of government offices in addition to the connection of state officials' homes has resulted in a greater willingness for state employees to spend time in Kasane, which apparently used to be regarded as one of the less favourable transfer destinations.

Security lighting has increased, the capacity for water provision extended, and communications improved, all at least partly because of the presence of electricity. The latter two have impacted favourably on other sectors in the area, with communications facilitating the operation of businesses, particularly the tourist industry, and water provision benefiting the domestic and commercial sectors.



The 32.5kVA backup diesel genset at the Prison. It used to be run all night to power security lights, now it is only run for maintenance purposes and during power cuts.

Where electricity has not impacted

Some departments are still operating on diesel generator power, and therefore are paying more for their energy than they would be if connected to the grid (although the sometimes substantial connection cost must not be forgotten). They also are without the conveniences of grid electricity brought about by its 24-hour availability, reduced maintenance requirements and higher reliability.

In addition, the slow rate of connection of many government offices will have delayed the benefits of electricity. In some cases, major government departments (Water Affairs) connected two years after electricity was available, while others connected even later.

The offices that are still awaiting approval of funds to connect deserve a special mention - they are particularly incapacitated by the lack of electrical office equipment and cooling appliances. The CTO is the most seriously affected. Not only do their offices become uncomfortably hot on a regular basis, but their workshop cannot perform operations such as drilling through steel and grinding or welding metal. They need to travel to other workshops to undertake such tasks. The use of a petrol generator to drive the government petrol pumps in also expensive and inefficient, and breakdowns are not uncommon.

Comparing impacts with those expected from the baseline study

The baseline study reported that 88% of departments expected to connect to electricity. The connection rate has to-date been higher (93%), and the remaining departments intend to connect. The rate of connection has, however, been slower than expected.

In the baseline study, many government departments thought that electricity was an important factor in the further development of their departments, and they expected to be more efficient and of better service to the public as a result of connecting. This appears to have been realised, with most offices now functioning more efficiently, and departments such as Water Affairs and Telecomms being able to provide better service, at least partly due to the presence of electricity.

Agriculture

Only Chobe Farms uses electricity, and thus its impact on agriculture in general is limited. The main areas where the farm is benefiting from electricity are in the running of coldrooms, which result in more efficient harvesting and probably reduced waste, and the ability to vary the pumping pressure for drip irrigation which the large diesel pump could not do. The remaining equipment mostly ran off generator electricity before grid connection. Here there is a cost saving and convenience benefit.

Chobe farms considers grid electricity to be very expensive, to the extent that they are considering reverting to genset use. If electricity connection was cheaper, the farm would also be more likely to connect up all the staff cottages, most of which are presently unelectrified.

No small farms use electricity, in spite of the potential benefit of electric water pumps to these farms. A small commercial poultry farm has a clear need for electric lighting, but the owners believe grid power to be too expensive, so are considering purchasing a generator. The farm is right next to an MV/LV transformer, and is potentially the closest customer to the BPC depot.

Comparison between actual impacts and those expected from the baseline study

The baseline study predicted that agricultural impact of electrification would be limited, particularly amongst small farmers, who did not consider electricity one of their priorities. The current use of electricity by farms in general indicates that these predictions have been reasonably accurate.

4.2 SOCIAL IMPACTS

Broadly speaking, the social impacts of electrification can be considered low, principally because the majority of households cannot afford the capital outlay to connect. Where electricity is available, however, the impacts are more noticeable. It should be noted that the social 'spinoffs' due to the economic growth impacts of electricity (such as employment creation), while not insignificant, are not specifically covered in this section.

Household welfare

It has often been difficult to assess the benefits of electricity on domestic welfare in the Kasane project, largely because the wealthier, more modern households tend to have electricity, while the poorer, often more traditional areas do not. Thus a comparison between electrified and unelectrified also means a comparison between groups with very different socio-economic characteristics. The benefits of electricity are nevertheless quite clear, and the following impacts could be identified:

Expenditure

Electricity replaces other lighting fuels (paraffin and candles) almost entirely, and also reduces the use of batteries significantly. The resulting energy expenditure is, in general, less than for equivalent houses without electricity. This is reinforced by perceptions of currently electrified houses, most of whom say that they are spending less than they would be without electricity. The impact of this is most significant for poorer households, who generally spend high proportions of their total income on energy.

Access to appliances

The most important benefit of electricity mentioned by both electrified and unelectrified households, related to the range of electrical appliances it allowed them to use. Amongst the most important appliances were fridges, allowing efficient storage of perishables and drinks. The improved refrigeration may also have had an effect on nutrition by facilitating the storage of fresh produce, making it more feasible to purchase such goods.

TV was also rated as an important benefit (presumably with a video). A TV set allows access to the outside world, and as a result, perceptions are broadened. One teacher in Kazungula remarked on the noticeable difference in children from a home with a TV set, suggesting that their repetoir of experience was that much greater.

Electricity is also a consistent power source for radios, and is widely used for this purpose. While not as powerful a medium as TV, radio also encourages an awareness of national and international affairs, and thus helps reduce the isolation of remote areas such as Kasane.

Cooling appliances, usually fans, are also widely used in electrified households. Some of the wealthier houses also have airconditioners. In this hot climate, the benefits of such appliances are obvious.

Quality of light

Adequate lighting facilitates a range of night-time activities, such as reading and sewing. Improved household lighting was considered an important benefit of electricity, both by connected households as well as those without electricity.

Convenience

Electricity is more convenient than other fuels. Although not mentioned as a priority amongst households, it is nevertheless a benefit experienced, as electricity users are relieved of the burden of frequently buying candles, paraffin and batteries - they just reach out and turn on the switch.

Health

A doctor at the hospital mentioned that paraffin poisoning is common amongst children. It is also recognised that use of paraffin and wood indoors can lead to respiratory illnesses. Although households did not raise health impacts as problems, current fuel use habits can impact on health. Electricity is a much cleaner source of energy, and the reduction in harmful emissions, as well as the reduced likelihood of paraffin poisoning must be kept in mind as a benefit of electricity supply.

The availability of electricity has facilitated the cold storage of fresh produce both in shops and at home. It is therefore likely that it has also impacted on household nutrition, principally in electrified households with a refrigerator, but also on any household that has access to a shop with electric refrigeration.

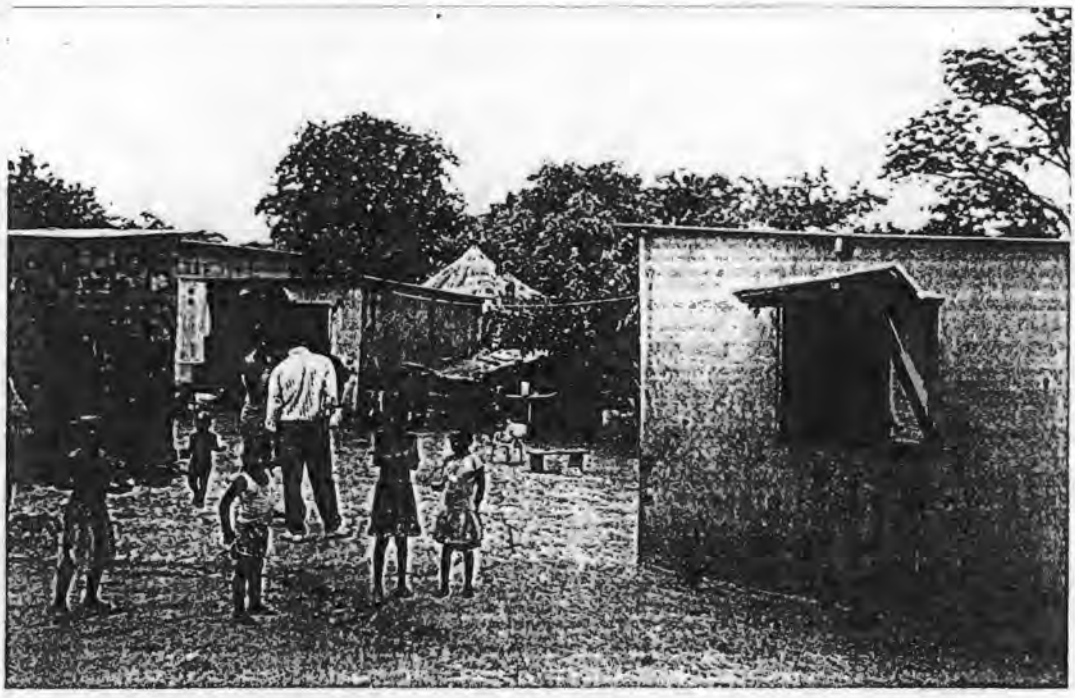
Household welfare: where electricity has failed to impact

If electrification is examined in terms of meeting basic needs and stimulating development of the study area, electricity has failed to improve household welfare for most of the population. This is because connection is presently unaffordable to the great majority in the SHHA and Kazungula settlements. In fact, connection fees are probably unaffordable to many houses outside of these areas as well, but in many instances they now reap the benefits of electricity because the state has paid for their connection - either because they live in a government house, or because they are in the Plateau area where the ALSP paid for the reticulation of the area and BHC paid for the connection. The overall effect has been that mainly the wealthier residential areas have benefitted by electrification. In SHHA and Kazungula, people still have to rely on inferior lighting sources, pay more for their energy needs, and have no access to the benefits of using electric refrigeration and other appliances.

It is interesting that electricity is used so little for cooking, in spite of its potentially greater convenience (gas bottles have to be purchased and transported periodically) and similar cost compared with gas (assuming conversion efficiencies as given in table 3.11).

No evidence to suggest that wood use patterns have been affected by electrification was found, largely because the main wood using areas are unelectrified. Judging by the expressed desire by unelectrified households to purchase electrical stoves or hot-plates, some measure of fuel substitution is likely to occur if these houses are connected.

The 'White City' government housing area - enjoying the benefits of electricity.



The SHHA area - only 3% of households have connected to electricity here.

Effect of the project on socio-economic disparities

Electricity is generally only used by the wealthier households. This is as a result of the high connection fee, and the funding of government and BHC house connections by the respective groups (BHC houses are on the Plateau). Electricity has therefore served to increase the disparities between different socio-economic groups. Amongst the government employees, electricity has benefitted the Permanent and Pensionable class (they live in state houses that have been connected), while the impact on Industrial class employees has been low.

Community facilities

Education

Lighting in classrooms for both rainy days and for nighttime study is probably one of the most important benefits of grid electricity at schools. The CJSS has the benefit of classroom lighting, while the two primary schools do not. Lighting is provided in teachers' accommodation at all schools, and has job satisfaction implications, which some teachers rate as equally important when compared with classroom lighting. The CJSS also has acquired satellite TV, which is facilitated by the availability of grid electricity, and this is also likely to have educational benefits.

The hospital

The benefits to the hospital of grid connection include the convenience of the 24-hour availability of lights in particular, and the reduced cost of power relative to generators. The use of a number of other appliances may also be linked to the availability of grid electricity.

Recreation

While the recreational facilities in the area are often considered inadequate, the impact of electricity on the available facilities has been noticeable. Grid connection has allowed for greater refrigeration capacity (in bars), improved lighting, and allows the operation of video games.

Street lighting

In the areas where street lights have been installed, people feel more comfortable about moving around at night, and it is also thought to be an effective deterrent to burglars. Street lighting is, however, not yet available in SHHA and Kasane central areas (although the former is currently having them installed).

Community facilities: where electricity has failed to impact

The main areas where electrification of the area has not fulfilled its potential benefit with respect to community facilities is that primary schools have no access to electricity, and street lights have not been installed in Kasane central.

Impact on women

The impact of electrification specifically on women has been low. Most households are unelectrified, and therefore have no access to electrical appliances which can facilitate domestic tasks. In most residential areas, such tasks are generally carried out by women. Although small farming is also undertaken largely by women, only the large commercial farm uses electricity, and therefore there has been no impact on women here either.

Women do not collect wood more than other family members, and therefore any fuel substitution which could occur due to electrification replacing wood use would not impact on women in particular. This substitution has in any case not been significant.

The role of women in government housing areas was often distinct from the other residential areas because a significant number of women are employed in key government posts. They are therefore the main breadwinners in many of these households, and were often found to be the principle decision-makers concerning appliance purchases. So there is no evidence to suggest that women are not benefitting adequately from the electricity supply in electrified households (of which most are occupied by government employees).

4.3 ENVIRONMENTAL IMPACTS

Adverse as well as positive environmental impacts of electrification are low. Adverse impacts seem to be limited to the construction phase and probably happened as a result of the lack of guidelines from BPC with regard to construction of transmission lines and the environment.

Removal of trees

Adverse impacts occurred with the construction of the transmission lines in the village Kasane when the contractors chopped down big trees in preparation for the construction of the lines. Interviews with the staff of the forestry department nursery indicated that the loss of two very old trees which were chopped down near and in the grounds of the Chobe Safari Lodge was serious. The seeds of the trees had been harvested every year for production of seedlings and trees in the nursery - the intention was to redistribute the trees to degraded areas.

Interviews with the manager of the Chobe Safari Lodge indicated that, although one of the trees was on their property, they were not consulted about the removal of the tree for the construction of the line. Besides the value as a seedbank, the tree had a high aesthetic value - and was an important asset/ feature for this tourist lodge.

The trees which were removed were:

- Mukamba (Afrazelia quanzensis)
- Mokaba (Acacia nigrescence)

According to the forestry department, no important trees were removed outside of the Kasane village area during the electricity line construction period. This information was corroborated by inhabitants at Kazungula. Inhabitants of the SHHA and plateau areas who were interviewed during this investigation could usually not comment on the environmental impact of the line, as they had been living in the area for less than five years or were ignorant about these impacts.

It is known that certain trees have great cultural value in Botswana. A reported story about the chopping down of sacred trees for the development of the Mowana Lodge resulted in further investigations. The story is:

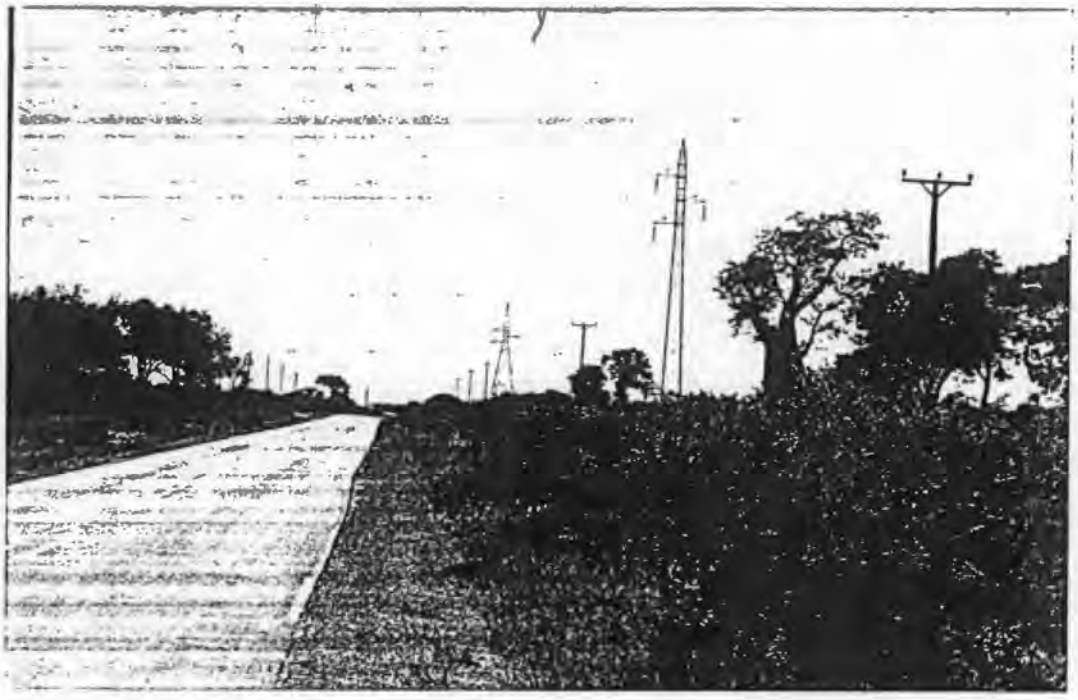
Mowana (Adansonia digitata - 'Baobab') trees were chopped down with the construction of the Mowana Lodge. This was a great sin against the spirits of the people who had lived (and were buried) under these sacred trees. Here the reports begin to differ - in some versions a medicine man subsequently places a bad spell on the Mowana Lodge; in the other version the spirit of the people who use to live under the trees placed the spell on the lodge. Mowana Lodge has been struck by lightning on at least two occasions during which it burnt down to the ground. Due to the obvious significance of these trees, further investigation into the possible cultural impacts of the chopping down the trees during construction phase was undertaken. Traditional medicine practitioners were interviewed in this connection. They corroborated the story of the Mowana trees but emphasised that the construction of transmission lines did not frustrate any cultural habits or ritual practises.

Impact of line maintenance

Maintenance of the transmission lines also have a low impact on the environment. The forestry department mentioned that the service roads and clearings which have been made for the maintenance and servicing of the lines have a beneficial impact on the management of the forest. The forests have hardly any fire breaks and few roads to patrol the forest. The clearings are seen as firebreaks by the department of forestry who can use the roads and clearings when they fight fires or when they investigate other problems. Interviews with the employees of the Chobe Game Park indicated that maintenance of transmission lines has had little, if any, impact on the game.

Visual impact

The overhead transmission lines running from Zambia to Kasane are seen by some of the inhabitants as an eyesore. People pointed out that tourists visit the area for its natural beauty and that the lines should have been buried - as was done in the Chobe Game Park. Some of the people interviewed pointed out that the developments in and around Kasane seem to be insensitive to the fact that this area is a tourist attraction, and that future developers should consider the natural beauty of the area and ensure that projects are aesthetically integrated. Most people did not, however, consider the lines to have an adverse visual impact.



The HV and MV lines running along the Kasane/Kazungula road. Some consider the visual impact to be significant, but most do not.

Impact on wildlife

Employees of the Chobe Game Park mentioned that the disruption of wildlife during construction was minimal. They considered the environmental impact of line construction to be low.

Electrification of the area has been a deterrent to elephants. Prior to electrification the elephants apparently roamed the Kasane area more regularly. However, the elephants are still a problem at the Plateau area, where people are sometimes terrorised by the animals and where the elephants often trample the fences surrounding homes. In this regard, one of the rangers of the Chobe Game Park mentioned that the elephants of Chobe are similar to the well known elephants of the Kariba in Zimbabwe - both these elephant communities have become so used to electricity that they are not deterred by streetlighting any longer. Electrical fences deter them only to a degree.

Chobe Game Lodge manager pointed out that the birdlife in the vicinity of the Lodge had improved in the area surrounding the genset rooms - apparently the recent quiet has attracted birds to that area. He considers the impact of electrification on game to be minimal. His opinion is of added importance, as he is one of few informed people who have been in the area for a long time.

Impact on firewood collection

As far as domestic energy is concerned, it is clear that electrification has not had a noteworthy impact on the frequency of firewood collections and use. The majority of the population at Kasane and environs as well as in Kazungula still rely on firewood for domestic energy. Forestry Department officials pointed out that the removal of dead wood from the forest had a positive rather than detrimental effect on the environment. Several licenses were issued to people to collect wood to sell. Policing of the license system is rare - this corroborates the notion that firewood gathering in this area is not seen as detrimental to the forest. There were no visible signs of a detrimental effect of firewood gathering in the neighbouring forests. In spite of this lack of impact, caution must be exercised in the future: the situation should still be monitored as there is an influx of people into the area and it is known that damage to forests (as a result of firewood gathering) is often realized at quite a late stage. Foresters are confident about the condition of the forest at present, and are even considering exporting firewood for domestic use into the surrounding areas - up to 70 km away.

The fact that domestic firewood is still a free commodity (no license is required to collect for domestic use - only for selling), and that wood is so cheap, supports the view that firewood is not scarce and that the gathering of firewood is not, at this stage, a threat to the forest.

Noise

The introduction of electricity to the area has almost eliminated the use of gensets, and therefore noise levels have been reduced. Residents did not, however, consider genset noise to be a serious problem in the first place.

Displacement

In one area, the HV electricity line runs over fields worked by small farmers from Kazungula village. Here the farmers do not consider that the interference of the line in their operations has been significant. In most other areas the line is routed along roads, and therefore does not conflict with other land use practices.

4.4 THE EXPECTED IMPACTS OF RURAL ELECTRIFICATION

Broadly, rural electrification aims to improve household welfare and to stimulate production in an environmentally sound manner. Some of the most common benefits associated with rural electrification are:

Households
- improved lighting in households
- increased access to a range of domestic appliances, including TV
- ameliorating problems associated with wood use, such as resource shortages
- less dependence on inconvenient fuels
- less dependence on more expensive fuels
- health benefits from reduced harmful emissions in houses from fuels such as paraffin and reduced incidence of paraffin poisoning
- impact on nutrition through the cold storage of fresh goods

Community facilities & services
- improve health via better equipped community health care services
- facilitate provision of domestic water via electric pumping
- impact on education via proper lighting and the use of other educational appliances
- enhance recreation and other night time activities, mainly via the provision of adequate lighting

Business & state operations
- improved work environment - lighting and cooling (or heating) for example
- increased office efficiency due to the use of office equipment
- replacement of usually more expensive and inconvenient diesel or petrol sets used for pumping and electricity generation
- ability to use electrical motors for pumping, workshop appliances, fridges/coolrooms etc.
- increased capacity of electricity supply over gensets, allowing for expansion in operations

Agriculture
- allow cheaper and more effective water pumping
- facilitates the use of productive electrical equipment

Environmental
- reduced woodland denudation

Comparing expected and actual benefits

To what extent has the Kasane/Kazungula rural electrification project achieved the benefits hoped for? Comparing the benefits commonly associated with rural electrification and those observed in this project, it is apparent that most of the expected benefits have been realised to some extent. The major differences arise from the project's failure to reach the majority of households, small farmers and small businesses. While the value of rural electrification is therefore reinforced by the observed benefits, the importance of ensuring that electricity is accessible to all is also illustrated. The likelihood of the impact on households, small farmers and small businesses being low was apparent from the time of the baseline study, which predicted low connection rates amongst these groups.

4.5 SUMMARY OF PROBLEM AREAS IDENTIFIED

Connection of households, farmworkers & other business accommodation

Failure to make electricity accessible to the majority of households in the area is considered one of the most significant shortcomings of the electrification project. Any potential to affect domestic tasks, often carried out by women, has therefore also not been realised, nor has the potential for reducing energy expenditure. Fuel substitution potentially resulting in lower utilisation of the surrounding woodlands has also not occurred.

- *potential remedy*: accessible connection charges

Street lights & security in Kasane

Provision of adequate streetlighting in one of the most important parts of the study area (Kasane central) is also a significant potential benefit of electrification that has not been realised to date. These would need to be paid for by Council.

- *potential remedy*: allocation of state funds

Connection of small businesses

As with the poorer households, smaller businesses cannot afford the connection fees for grid power.

- *potential remedy*: accessible connection charges

Connecting primary schools

This is apparently not a high priority for the state. Although even lighting alone would benefit these schools, money would also be required for other electrical equipment if the impact is to be maximised.

- *potential remedy*: allocation of state funds

Electricity use by small farms

Although not amongst their priorities, some potential exists for small farmers to benefit from grid connection through water pumping and irrigation. Again, the connection costs presently make this option unaffordable.

- *potential remedy*: accessible connection charges

Expense of security lights

Some business would not install adequate security lights due to the increased electricity bills that would be incurred. The current theft losses to these businesses may be reduced by using such lights.

- *potential remedy*: special tariffs for such loads (as Kasane is unusual w.r.t. the crime problem, BPC could consider a tariff closer to their electricity purchase price from Zambia, offer discount to such consumers, or institute off-peak tariffs. These measures could be motivated by the economic benefits likely to result)

Expenses of demand tariff for seasonal loads

Some tourist related businesses have highly seasonal loads, but are nevertheless subject to a high demand charge all year round because of the BPC 'Business 2' tariff structure.

- *potential remedy*: consider modifying the demand charge to allow for seasonal variations

General expense of electricity

Most larger consumers considered electricity tariffs to be high, to the extent that many were considering reverting back to generator use, at least partially. One such consumer was the large commercial farm in the area, which was paying large sums for water pumping.

- *potential remedy*: there may be scope for tariff restructuring to ease the burden on these consumers, or designing a more favourable water pumping tariff for farms (the present water pumping tariff would not reduce payments by much). Also, users could be made aware of the comparative costs of gensets versus grid power.

Economic cost incurred due to poor quality of supply

Almost all computers encountered were running off a UPS to intercept the power spikes which occur. Some fridges also had protection. Also, many businesses still had backup generators due to the frequency of power outages (although these occurred mainly in the early years of connection, and are not generally considered a problem now). The expense of these protection measures or of maintaining a backup genset on the economy could be avoided by improved supply quality.

- *potential remedy*: surge interception at the BPC transformer, and MV circuit 'rings' to minimise areas affected by outages (although the economics of these measures may not prove feasible)

Bills, tariffs and connection costs not understood, BPC considered inefficient

Many users of all tariff categories did not understand their bills, nor the structure of their tariffs. Tariff options and cost implications before connecting (applicable to business 1 & 2 mainly) were also often not understood. A number of potential or existing consumers also considered gensets to be cheaper than grid electricity, which is almost always not the case. Many households 'knew' that electricity was very expensive to obtain, but had heard this from other residents rather than from BPC.

In a minority of cases, BPC was also considered inefficient, partly because bill and tariff queries were not easily answered by the BPC depot, which appears to be largely technically oriented and has no revenue or marketing functions.

- *potential remedy*: improvement of consumer information services at the BPC depot, including active information dissemination.

CHAPTER 5

FINANCIAL AND ECONOMIC COST-BENEFIT EVALUATION

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FINANCIAL AND ECONOMIC COST-BENEFIT EVALUATION

5.1 INTRODUCTION

The objective of the financial and economic analysis is to further assess the viability of the Kasane electrification project. The underlying objective is to compare the electrification project with the hypothetical situation of grid electricity not being available in the area.

The capital investments, expenses, receipts and benefits to date are assessed here and evaluated using standard techniques. Two scenarios are proposed for the future growth of electricity demand in the area, and projections are made based on these scenarios. Scenario one assumes levels of growth based on past trends (but constrained by population limits). Scenario two encompasses a shift in policy towards improving the access of households to electricity. The proposals contained in this scenario can then be tested using the analysis techniques adopted.

Three levels of analysis are performed:

(i) the first is a straight-forward financial analysis of the project from BPC's viewpoint. The costs and returns here are those seen by BPC.
(ii) the second level of analysis examines the effect of capital subsidies, i.e. the original CIDA grant and the Botswana government's ALSP grant are removed and the analysis treats the project as though BPC had paid for the entire existing infrastructure.
(iii) The third level is the economic analysis where additional benefits are quantified and included. Each level is presented for the period from the start of the project to the present and for two future scenarios.

5.2 METHODOLOGIES

A financial analysis is sufficient for project appraisal if market prices express reasonably well the economic cost and value of different items. If grants, subsidies and/or taxes distort the true cost or benefit of an input or output, then it is necessary to revalue these items. Similarly, if the value of foreign currency is underestimated, a more realistic value may affect the profitability or value of a particular project.

The evaluation of the project requires that the capital costs, expenses, receipts and benefits are enumerated for each year of the project's life. In the standard way, annual cash flows can be calculated and these values discounted to yield a nett present value (NPV) of the project. The internal rate of return (IRR), i.e. the discount rate at which the NPV is zero, can then be calculated (IRR and NPV are explained later).

How "costs" and "benefits" are identified depends on the point of view adopted. In this case, the financial analysis is based on the viewpoint of the electricity supply utility, i.e. BPC. Here the costs are the actual outflows seen by BPC during the course of the project and the "benefits" are the receipts due to electricity sales and contributions towards the establishment of infrastructure, both from grants and customers. The economic analysis is an attempt to evaluate the project from the national viewpoint and the costs and benefits refer to the national resources that are used or generated as a result of the project.

In many rural areas, incomes are low and large numbers of people live at or close to the subsistence level. The demand for electricity is consequently small and many households would be unable to afford either the connection fee or new electrical appliances. Multiple fuel use patterns are a common feature of both unelectrified and newly electrified areas. The experience, both in Southern Africa and in Kasane, is that multiple fuel use patterns persist, albeit in a changed form, after the introduction of electricity. This, together with low levels of domestic access, limit the potential benefits arising from the introduction of electricity into an area. A key strategy to maximise the benefits arising from investment in electricity distribution infrastructure, is to facilitate increased levels of domestic access.

The links between electrification and development are often cited as reasons for supporting rural electrification. However, access to electricity is a necessary rather than sufficient condition for bringing about economic development. A question arises whether or not the development promoting impact of rural electrification is such that it makes the use of standard economic accounting techniques inappropriate. Reasons typically advanced for the special nature of rural electrification include:

- rural electrification benefits the poor;
- rural energy problems are complex and electrification may offer an easily replicated solution;
- rural electrification acts as a catalyst to development, both agricultural and industrial;
- rural electrification may help to stabilise rural areas and reduce rural to urban migration;
- rural electrification has many social benefits and can improve the quality and extend the range of available energy services.

Pearce and Webb (1989) investigate this question and conclude that traditional cost-benefit analysis techniques are appropriate to the assessment of rural electrification projects. However, it is important to bear in mind that the total benefits will be difficult to quantify and will extend beyond the quantifiable elements such as productivity improvements, savings due to fuel-substitution and consumer-surplus gains. Any impact on community facilities such as hospitals or schools, the benefits of street lights, and household impacts such as greater convenience, improved quality of light, and health or nutrition benefits must be considered in addition to the economic cost-benefit analysis.

IRR and NPV

Internal rate of return (IRR) and net present value (NPV) are two parameters which provide information on the viability of a project. IRR relates to the return on capital invested, and NPV to actual monetary value resulting from the project or analysis, discounted to present value. If the NPV is positive, it indicates that, for the discount rate used, the project is viable. If the NPV is positive, the IRR will be greater than the discount rate. If the return on capital invested is lower than the discount rate, the monetary value of the project returns will be negative if discounted to present value using this rate (i.e. if the IRR is lower than the discount rate, the NPV must be negative).

Financial analysis: costs and returns

The costs to be included in the financial analysis include both capital expenditure and operating costs. The capital expenditure includes the following:

- the 66kV line from Zambia and the sub-station at Kasane;
- the medium voltage distribution network;
- the local transformers and low voltage distribution network;
- the BPC maintenance depot.

The operating expenses include fixed costs and maintenance costs as well as electricity purchases from ZESCO.

The receipts include grants from donors and the Botswana government, and customer contributions to the capital costs as well as revenue from electricity sales. The grants made available over the course of the project include the original CIDA grant to establish the 66kV link-up and medium voltage network as well as government contributions through the ALSP.

Time horizon, discount rate and tariff escalation

Rural electrification equipment has a long lifespan and if properly maintained, its useful life may be indefinite. For this reason a relatively long lifespan of 20 years has been chosen for the evaluation. The initial investment was made in 1986 and electricity became available in 1988. The analyses are taken to the year 2005.

It is difficult to accurately estimate the discount rates to be used for the financial and economic analyses. The discount rate in the financial analysis should reflect the cost of capital to BPC. This can be estimated by examining the rates on loans to BPC, or the return that BPC could expect on its equity. World Bank loans to BPC require a 8% real rate of return on capital assets. However, BPC has a policy to maintain tariff increases below inflation, consequently a return of around 5 to 6% is achieved. In this analysis a discount rate of 6% is used for the financial analysis. The discount rate used for the economic analysis should reflect the opportunity cost of capital in the Botswana economy. Again, this can be difficult to estimate, and a conservative estimate of 6% is made for this. Sensitivity analyses are performed on these variables.

BPC's monthly tariffs and connection fees for the years 1988 to 1994 have been used. Over the past six years, these have escalated at a rate 4% below the inflation rate, i.e. a real decrease in tariffs. It is likely that this trend will continue as there are pressures tending to reduce BPC's long range marginal cost of electricity supply. It is assumed that electricity tariffs will continue to decrease in real terms for the next six years. Thereafter, tariff increases are assumed equal inflation. A sensitivity analysis is performed on the rate of tariff increase.

Table 5.1 Assumed Real Tariff Increases for Analysis Period

Real Annual Tariff Increases							
1994	1995	1996	1997	1998	1999	2000	2001 +
-5%	-5%	-5%	-4%	-3%	-2%	-1%	0%

Technical and non-technical losses are included in the analysis. Technical losses include transmission losses through the Kasane/Kazungula distribution system. These have been around 5% over the past few years, and BPC recommends that this figure be used for future projections. Non-technical losses included arrears on electricity bills. Comparing electricity supplied to the revenue from sales, it appears that these losses amount to about 8% of expected revenue. This figure is used for future projections.

Adjustments to produce the economic analysis

A number of adjustments are made to the financial analysis to transform it from the viewpoint of the power utility to the viewpoint of the nation. The main adjustments made include: the exclusion of financial transfers[1]; the inclusion of national savings due to reduced energy

[1] This refers to money which is not a gain to the economy, but is merely transferred from one sector of the economy to another, such as from individuals to the state (taxes), or from donors to BPC (grants).

expenditure; the consumer surplus due to the benefits of electricity beyond the price paid for it; and the benefits of multiplier effects on the local economy.

Transfers

Any grants made available were excluded from the enumeration of returns. In particular the initial capital subsidy from CIDA was excluded, thereby reflecting the real cost of establishing the infrastructure. Subsequent grants from the Botswana government through the ALSP were used to extend the network and provide street lighting. This subsidy was removed from the analysis[2].

The figures used in the financial analysis excluded tax and so it was not necessary to remove taxation transfers.

Fuel substitution savings & consumer surplus

Included in the economic analysis is a quantification of savings arising from the substitution of other forms of energy displaced by electricity use. For the domestic sector, the investigation revealed that the fuel mix in electrified homes was substantially different from that in non-electrified homes. Certain fuels were displaced completely whereas others were only displaced partially. For businesses and agriculture, the main substitution is from diesel genset systems to grid electricity supply.

Access to electricity increases that range of energy services that become available. It is likely that a consumer, either domestic or business, will increase the quantity of useful energy consumed. This increase in useful energy consumption is quantified for different categories of consumer and included as a benefit.

The consumer surplus is the difference between consumers' willingness to pay for electricity and the actual price they have to pay. A straight line demand curve is assumed, as shown in figure 5.1, and the consumer surplus quantified.

It should be remembered that these benefits do not include a range of benefits, such as the convenience of electricity in the home or business, or educational benefits due to improved lighting etc.

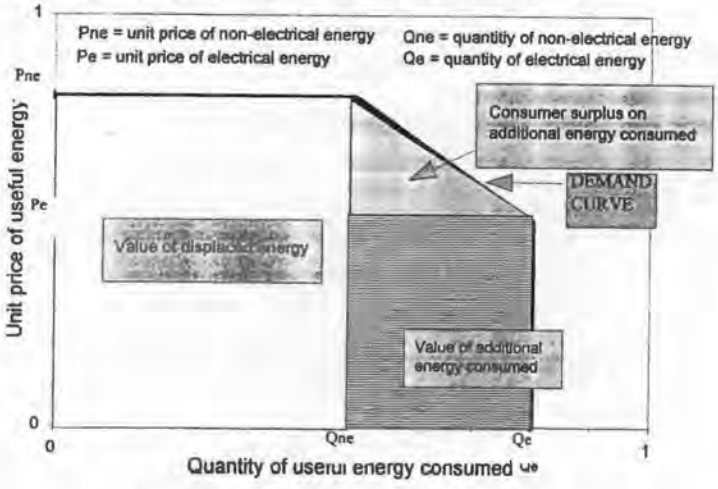

Figure 5.1: Additional benefits

Multiplier effects on the local economy

The influence of electricity on the local economy has been significant. Interviews revealed that a number of businesses would not have established themselves without electricity being available. Other businesses indicated that the availability of electricity has increased their turn-over and profitability. Based on these interviews, estimates were made of the number of jobs created as a direct result of the introduction of electricity. A percentage of the annual salary bill for these jobs was taken as the annual, recurring benefit due to job creation.

[2] In many cases the electricity bills and connection costs for government departments and government employees' houses are paid for by the government. In these cases this is not viewed as a grant but the government department concerned is treated as a paying customer.

Foreign exchange

There are a number of foreign exchange implications in the project. The initial infrastructure had a foreign exchange component; the electricity purchased from ZESCO is paid in US currency; and imported fuel (such a diesel and paraffin) is displaced by the introduction of electricity. However, Botswana does not have a shortage of foreign exchange and in fact reserves have been steadily increasing over the past ten years. It is assumed that exchange rates reflect the true value of import/export transactions to the Botswana economy and for this reason, no shadow pricing of foreign exchange is incorporated in the analysis.

5.3 PROJECTED SCENARIOS

In order to evaluate the project over the time horizon selected, i.e. to the year 2005, it is necessary to assess future costs and receipts. In particular, growth in demand is the critical factor which will affect the financial and economic viability of the project.

Two scenarios have been proposed here. The first scenario is based on an extrapolation of current consumption trends, constrained by limits on population size. The second scenario assumes that further investment is made in the electrification of the domestic sector, in particular Kazungula, the SHHA and the currently undeveloped SHHA area on the Plateau (note that the Plateau area is divided into the fully occupied housing development and the serviced but still unoccupied SHHA plots).

Scenario one

The number of actual or potential consumers in Kasane/Kazungula is divided into different consumer categories and consumption types. These are repeated in table 5.2, together with the present electrification figures.

Growth in number of consumers

Although the population of Kasane/Kazungula can be expected to grow over the next ten years, the number of dwellings and potential electricity connections will be limited by the availability of sites. Five hundred new SHHA sites developed on the Plateau area have recently been allocated and it is expected that within the next two years all these sites will be occupied. The River Front area presently has 16 out of 25 sites developed and it is assumed that the remaining nine sites will be developed during the course of the next five years. Otherwise, all sites in the areas of White City, Plateau (housing) and Kazungula are already fully occupied.

Although the population has been growing at a rate above the national average since 1986, much of this has been due to the influx of people seeking work on the large construction projects over the past five years. Also, an effect of the 1992/3 drought was that people in outlying rural areas migrated into rural centres such as Kasane. It is unlikely that these growth trends can be expected to continue over the next ten to fifteen years. Assuming a population growth of 5% per annum (the estimated growth rate for '94), there would be a demand for a further 700 sites by the year 2000. The scenario assumes that at this time a further 700 sites, similar to the Plateau SHHA area, are developed.

At present almost all houses in White City & Government category are electrified as are houses in the Plateau area and on the river front. Current electrification in Kazungula and SHHA stands at 5% and 3% respectively. The major obstacle to new connections in these areas is the high costs of connection and it is assumed that this barrier will effectively prevent the majority of households from gaining access to electricity. It is assumed that the level of connection will gradually rise to 7% over the next four years in these areas.

In the SHHA area on the plateau, a more developed reticulation system exists and it is expected that more consumers would be able to afford the connection costs. In this area it is assumed

that the number of consumers would increase over five years to 30% of the total. Similarly, in the assumed new development of 700 sites in the year 2000, it is assumed that the level of connection will reach 30% within two years.

The number of government users is assumed to grow at an annual rate of 5% per annum. In the business sector, the largest category of consumers is "Business 1", i.e. loads that do not exceed 35kW. The number of businesses in this category is also assumed to grow at a rate of 5% per annum. In the "Business 2" categories, growth is limited to one new customer every two years. At present there are no "Business 3" consumers (the only consumer in this category closed in 1991). Here it is assumed that only one consumer in this category opens during the time horizon considered.

Table 5.2: Domestic Consumers in 1993

Residential area	Number of sites	Number of occupied sites	Number of consumers	Current electrification
Kazungula	123	123	6	5%
SHHA	480	480	14	3%
Plateau - houses	215	215	215	100%
Plateau - SHHA	500	0	0	n/a
Government	145	145	140	97%
River front	25	16	15	94%
Other*	8	8	8	100%
TOTAL	**1496**	**987**	**398**	**40%**

* - estimate of other accommodation at border posts, prisons etc. for '93.

Growth in electricity consumption

The growth in consumption is based on the assumed growth in the number of consumers and average consumption figures for different consumer categories, based on BPC records over the past five years.

In the domestic sector customers connected in the first few years tended to be high level consumers and more recently connected customers have used less, resulting in a steady decline in the average consumption over the past five years. For this reason, the average domestic consumption is assumed to be slightly lower than the long term average. In 1994 the average domestic consumption per household is assumed to be 180kWh/month, climbing by about 5% per annum until it reaches a peak of 220kWh/month (10% less than the domestic average for 1989). Figure 5.7 presents average consumption figures for credit-billed domestic consumers.

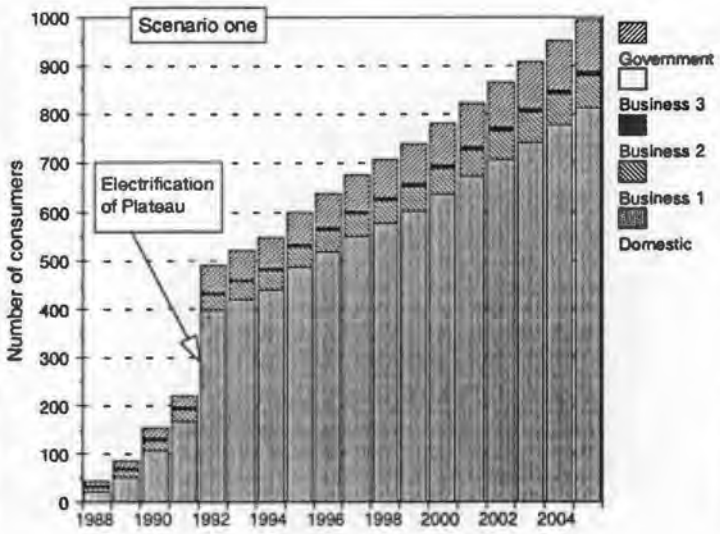

Figure 5.2: Growth in number of consumers scenario one

For other categories of consumers the average consumption figures are presented in table 5.3. It is assumed that these averages remain consistent over the next eleven years and growth in electricity consumption in these categories is a function of the growth in the number of consumers.

These assumptions lead to an average annual growth rate in total electricity consumption of 6% per annum.

Table 5.3: Current consumption information for different categories of consumers

Tariff category	Number of consumers*	Ave. consumption per consumer [kWh/month]**	Total consumption for group* [MWhr/yr]
Domestic	398	204	559 (19%)
Business 1	32	1 415	690 (23%)
Business 2	5	14 767	1 110 (37%)
Business 3	0	3 292	0 (0%)
Government	56	1 417	642 (21%)
TOTAL	**491**		**3 000 (100%)**

* - for 1993
** - for 1989 to 1993

Costs and returns

The full costs of new connections are paid for by new consumers. This would include the cost of any medium voltage line required, a transformer (possibly shared) and a connection fee to the site which includes 30m of low voltage wire, a distribution board and meter. For domestic consumers a single-phase connection fee is currently P1 135 and for business consumers, a three phase connection fee is P3 065 (excluding any line extension costs).

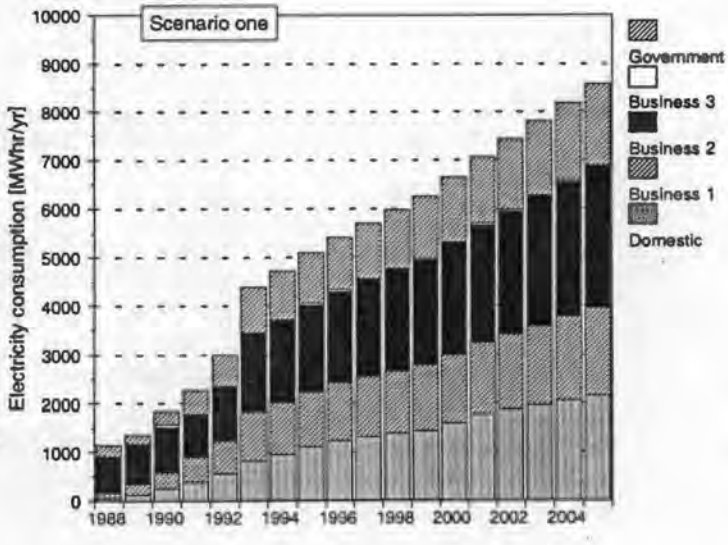

Figure 5.3: Growth in consumption scenario one

To date, the average new connection cost for both a new domestic and business consumer (including all line extension costs) has been in the region of P6 000 (in 1994 terms). Estimated full connection costs for future consumers vary depending on the site. For new businesses, the average connection cost is assumed to equal the average over the past few years, i.e. P6 000 per connection. For new domestic consumers in the SHHA, Kazungula, White City, the River Front and the assumed new 700 house development in the year 2000, the average connection cost is assumed to be P4 000. For new connections in the SHHA area on the Plateau, where much of the reticulation infrastructure already exists (no new transformers need to be installed or MV lines built), the average connection cost is assumed to be P3 000 (in keeping with BPC

estimates of average connection costs for urban consumers of around P3 000 per new connection).

Table 5.4: Costs of future new connections - scenario one

	Average connection cost*	No. new connections 1994-2005**	Present value of all new connections[1]
Plateau SHHA	P 3 000	150	P 380 000
Other domestic	P 4 000	392	P 640 000
Business & Govt.	P 6 000	74	P 330 000
TOTAL	**P 4 060**	**351**	**P 1 350 000**

* - in 1994 Pula, discounted at 6%
** - based on scenario one projections

The present value of all projected capital expenditure by new customers (in 1994 Pula, discounted at 6%) is calculated to be P1 350 000.

Electricity purchase costs and revenues from electricity sales are based on projected energy demand. Peak demand due to growth in demand from the non-domestic sector is expected to grow in proportion to this growth. Peak demand due to the domestic sector is assumed to be 1.25kW per consumer. This is based on BPC estimates of between 1 and 1.5kW ADMD per domestic consumer.

The history of fixed costs shows that the total annual amount can be modelled as a cost of P85 000 plus P267 per customer.

Table 5.5: BPC's overheads in Kasane

Year	1987	1988	1989	1990	1991	1992	1993
Overheads (nominal terms)	P91 000	P95 000	P100 000	P108 000	P116 000	P177 000	P216 000
Overheads (in 1994 terms)	P200 000	P191 000	P186 000	P179 000	P172 000	P236 000	P248 000
Overheads per customer (in 1994 terms)	P25 000	P4 400	P2 100	P1 200	P780	P481	P475

Scenario two

This situation is based on scenario one, with the exception that a major initiative is made to electrify domestic dwellings in Kazungula, SHHA, and the new Plateau SHHA development areas. It is assumed that by 1995 reticulation infrastructure is developed in all domestic areas and that the take-up rate is 80%. The preferred technology for these newly electrified areas is the use of prepayment meters. This technology has been successfully utilised by Eskom in areas of South Africa. It has the advantage that consumers can more easily regulate their electricity consumption, adapt expenditure to their income and match it to the periodicity of income. The utility does not have to individually read meters and will not sustain bad debts.

The electricity consumption for these newly electrified areas is assumed to be lower than the consumption for other areas, as incomes are generally lower. For consumers using the traditional credit billing system, an average consumption of 180kWh/month is assumed, increasing to 220kWh/month, as for scenario one. For prepayment metering systems, an initial

average consumption of 150kWh/month is assumed, also increasing to 220kWh/month over time. Figure 5.7 presents these consumption rates.

The number of new businesses and government offices and the associated growth in electricity consumption is assumed to be the same as for scenario one.

Additional Capex

The additional costs, beyond electricity purchases and operating and maintenance expenses, include capital expenditure to extend the reticulation system. The areas where infrastructure needs to be developed include Kazungula, SHHA and the SHHA area on the Plateau. Estimated costs (given in 1994 terms) to develop this infrastructure and to connect 80% (the assumed take-up rate) are given in table 5.6. Costs are based on guidelines by BPC. It is assumed that each site would be provided with a ready board and prepayment meter. The total cost per household (again assuming an 80% take-up rate) is P2 500. BPC's estimate of costs for urban sites (and for costing purposes, these sites resemble urban settlement densities) is about P3 000 per site. Given that a certain amount of infrastructure already exists, the P 2 500 estimate appears reasonable.

An additional area where a reticulation system would be developed is in the assumed new development of 700 sites in the year 2 000. Assuming a cost of P3 000 per site, the cost of the electricity reticulation and household connections would be approximately P2 100 000 or P1 500 000 in present value terms (discounted at 6%).

Table 5.6: Capital costs to extend electricity distribution to unserviced areas

	Unit cost	SHHA	SHHA - Plateau	Kazungula
New consumers		480	500	120
Cost of transformer	P13 100/100kVA P14 800/200kVA	P59 200	- - -	P26 200
Low voltage line cost	P30 000/km	P270 000	P375 000	P60 000
Medium voltage line cost	P31 000/km	- - -	- - -	P6 200
Connection costs*	P1 135/h'hold	P544 800	P567 500	P136 200
13.75% administration & location charge**		P120 175	P129 594	P31 433
TOTAL		**P994 175**	**P1 072 094**	**P260 033**
GRAND TOTAL		**P2 326 302**		

* - Standard single phase connection cost: it covers 30m of low voltage cable, distribution board and meter

** - Standard surcharges used by BPC in calculating electrification costs

Table 5.7: Costs of future new connections - scenario two

Area	Present value (in 1994 terms, discounted at 6%)
Kazungula, SHHA & SHHA Plateau	P2 215 525
New housing development in the year 2000	P1 567 052
New business & government connections	P330 000
TOTAL	**P4 112 577**

These costs, together with the future cost of new connections in the assumed new development, result in a present value of total capital expenditure for new domestic connections (in 1994 Pula, discounted at 6%) of P3 700 000. As for scenario one, the present value of total costs of new business connections is P330 000. The present value of all new capital expenditure is just over four million Pula (table 5.7).

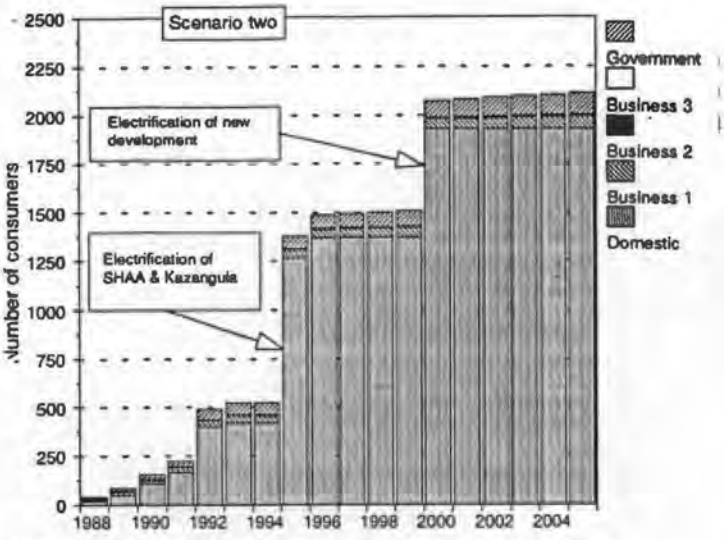

Figure 5.4: Growth in number of consumers scenario two

Pre-payment meter tariff

It is proposed that BPC finance this infrastructure and recover the cost through a special tariff for prepayment meters. This tariff, being designed for application with prepayment meters, would consist of only an energy charge. This charge would be comprised of three components: a standard energy charge equal to that paid by other domestic consumers; a surcharge to cover fixed costs (i.e. the P7/month paid by other domestic consumers); and an additional surcharge to pay back the capital expenditure on infrastructure. Such a tariff has been used successfully in South Africa. The level of the tariff is sensitive to connection costs, average levels of consumption, interest rates and payback period. Assuming a payback period of ten years, figures 5.5 and 5.6 present the sensitivities to the other variables.

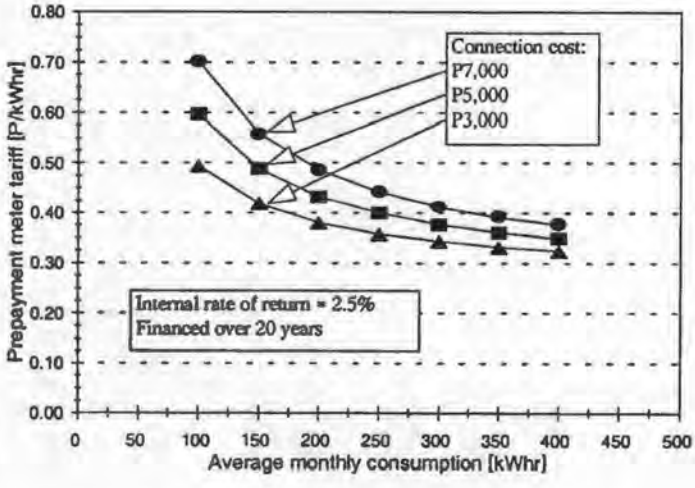

Figure 5.5: Sensitivity of prepayment meter tariff to connection cost

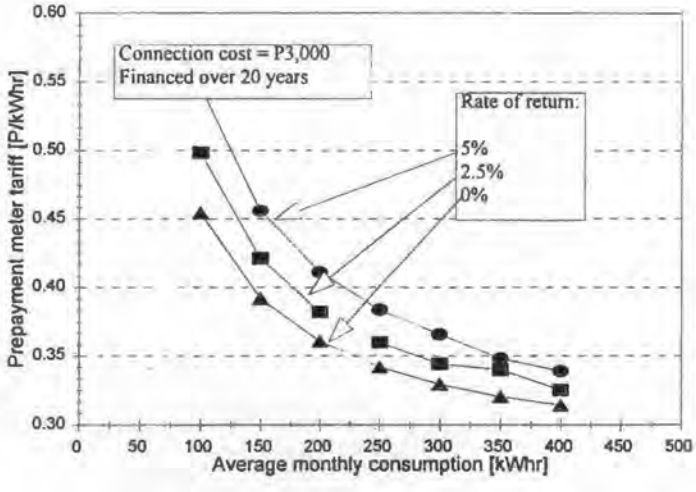

Figure 5.6: Sensitivity of prepayment meter tariff to required IRR

Assuming a capital cost of P3 000 per household connection, an average consumption of 200kWh/month, a real interest rate of 2.5% and a payback period of twenty years, the tariff would be made up of the following amounts:

Standard energy charge:	26.7 thebe/kWh
Fixed cost surcharge:	3.5 thebe/kWh
Capital repayment surcharge:	7.9 thebe/kWh
TOTAL	**38.1 thebe/kWh**

The average monthly bill using this tariff, assuming a consumption of 200kWh per month, would amount to around P76 per month. This is not too far off the existing energy expenditures in the area (the overall average is P 84 p.m., in SHHA P 102 p.m., and in Kazungula P 47 p.m.). Some users would of course use more electricity, and some less (100kWh per month would cost P 38, and 300 kWh per month would cost P 114).

Revenue

Revenue under this scenario will arise from electricity sales to customers using credit meters (using the standard domestic tariff) and sales to customers using prepayment meters (using the proposed tariff). Figure 5.7 presents past trends in consumption rates and projected rates for both scenario one and scenario two. Figure 5.8 presents the estimated levels of consumption under this scenario.

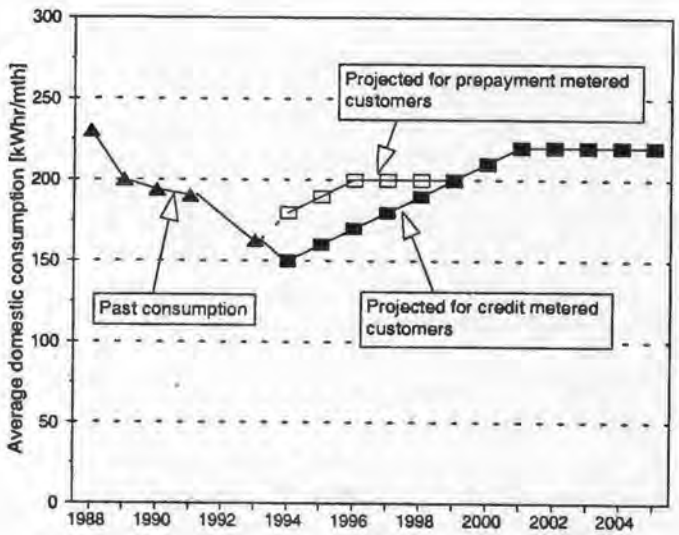

Figure 5.7: Past and projected domestic consumption rates - prepayment meters and credit customers

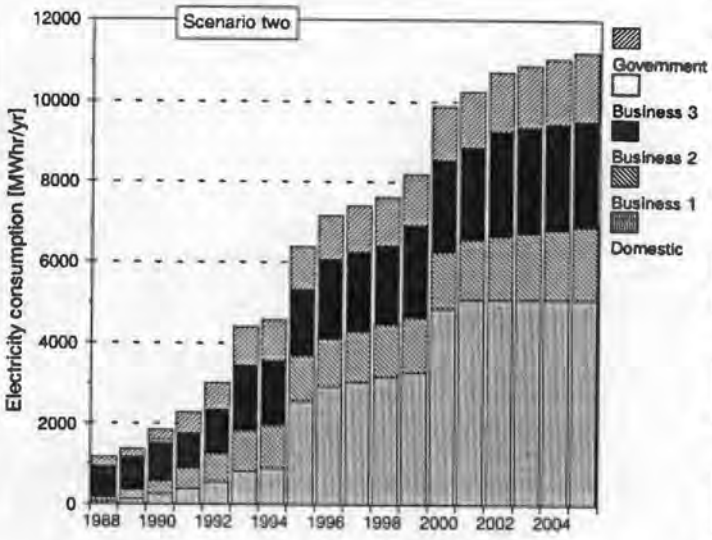

Figure 5.8: Growth in total consumption for the area - scenario two

5.4 FINANCIAL ANALYSIS

The major costs and receipts from BPC's point of view are presented here, together with the resulting cash flow and financial analysis. All figures presented in tables and graphs are expressed in 1994 terms.

Capital expenditure

The capital expenditure includes the original establishment of the 66kV line and sub-station, the medium voltage reticulation system, the establishment of depot buildings and household and commercial/industrial connections.

The original CIDA grant, made in 1986 totalled P5 600 000 (P13 600 000 in 1994 terms) and covered the 66kV line to Zambia, the sub-station, 30km of medium voltage reticulation, including a contribution towards the cost of the underground line inside the Chobe game reserve, and other capital items. The CIDA grant, BPC, the Lodge and the government each contributed 25% towards the cost of the underground line to Chobe Game Lodge.

Connections commenced in 1988 and over the past five years a total of P2 200 000[3] has been paid to BPC by private consumers and government institutions. Under scenario one, a further P1 350 000 (present value, discounted at 6%) is paid by new consumers over the timespan of the analysis. Under scenario two, an amount of P4 000 000 (present value, discounted at 6%) is invested by BPC in establishing reticulation infrastructure in unserviced residential areas.

In 1992 the accelerated land servicing programme paid for electricity reticulation to newly developed industrial and commercial sites near Kazungula, the extension of the reticulation system to newly developed commercial sites in Kasane as well as the reticulation of electricity on the Plateau area. The total investment in electricity infrastructure came to about P835 000 (P1 100 000 in 1994 terms).

Operating expenditure

Operating expenditure includes variable costs, i.e. bulk electricity purchases from ZESCO, and fixed costs. Electricity purchases are based on the tariff given in the table below. The future tariff is assumed to escalate at the same rate as inflation, i.e. no real increase. Since this tariff is paid in US dollars, this assumption would depend on future exchange rates and the situation in Zambia.

The fixed costs include maintenance, billing and service costs, salaries and overheads. These were estimated at P400 (in 1994 terms) per customer per year. This estimate was based on an analysis of past trends in the Kasane area.

Table 5.8: Schedule of tariffs over time, expressed in nominal prices

Category	Charges	1988	1989	1990	1991	1992	1993
Domestic	Basic [P/month]	2.47	2.60	4.00	6.00	7.00	7.00
	Energy [th/kWh]	20.9	22.36	23.65	24.8	25.75	26.7
Business 1	Basic [P/month]	2.47	2.60	10.00	15.00	17.00	17.00
	Energy [th/kWh]	23.45	24.39	25.1	25.5	26.7	27.2
Business 2	Basic [P/month]	2.47	2.60	10.00	15.00	17.00	17.00
	Energy [th/kWh]	11.6	12.35	12.66	13.1	13.7	14.2
	Demand [P/kW]*	27.00	28.00	30.50	32.00	33.50	34.00
Business 3	Basic [P/month]	2.47	2.60	10.00	15.00	17.00	17.00
	Energy [th/kWh]	10.15	10.72	11.26	11.8	12.3	12.8
	Demand [P/kW]*	26.00	27.00	28.50	29.50	30.90	23.00
Govt.	Basic [P/month]	2.47	2.60	10.00	15.00	17.00	17.00
	Energy [th/month]	27.15	28.25	29.66	30.7	32.2	34.0
ZESCO**	Basic [P/mnth]	701.54	777.26	718.54	779.19	824.00	965.78
	Energy [th/kWh]	2.18	2.41	2.23	2.42	2.56	3.00
	Demand[P/kVA/mnth]	5.99	6.64	6.14	6.66	7.04	8.25

* - Based on greater of: actual demand supplied, or 90% of peak demand over previous 12 months.
** - Based on following constant US$ charges: Basic = $386.31; Energy = $0.012/kWh; Demand = $3.30/kVA.

[3] costs in this section are in 1994 terms unless stated otherwise.

Revenue

There are three main sources of revenue to BPC: firstly grants, both from the CIDA grant and through the Botswana government's ALSP; secondly contributions to capital expenditure from customers (including private households, businesses and government offices); and thirdly revenue from electricity sales. Grants and customer contributions have been described under capital expenditure above. Revenue from electricity sales for previous years is based on figures made available by BPC. Revenue for future years is based on demand projections described above. In scenario two, new consumers on prepayment metered systems pay a different tariff which include energy charges, fixed-cost charges and capital-redemption charges. This tariff is set at 38.1 thebe/kWh for this analysis.

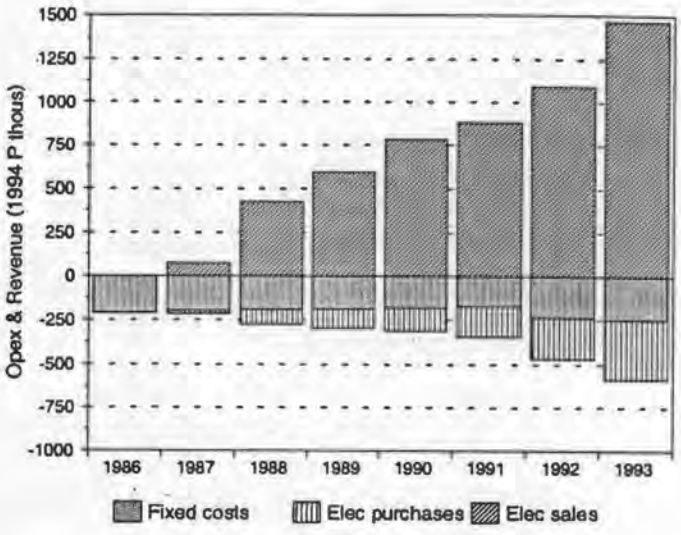

Figure 5.9: Financial analysis - expenses & revenue: 1986-1993

Return on Revalued Assets

Assuming that P5.5 million of the initial grant was capitalised on BPC's books, and depreciating these assets over 30 years (straight line depreciation), and revaluing them in line with inflation, the nominal return on these assets for 1993 is estimated to be 3%. Table 5.9 presents the return on revalued assets for the past five years. If BPC capitalised a smaller portion of the initial grant, then the return would be proportionately higher.

Table 5.9: Return on Revalued Assets

1987	1988	1989	1990	1991	1992	1993
-4.5%	-2.7%	-1.6%	-0.3%	0.2%	0.8%	3.0%

Analysis from 1986 to 1993

Figure 5.10 presents the nett annual cashflow and cumulative cash flow for the period 1986 to 1993. The cumulative cash flow turns positive in year five (1990) and the nett present value of the project over this period (excluding any residual value), assuming a discount rate of 6% is P1.6 million (in 1994 terms). The internal rate of return for this period is 43%, indicating a significant return for BPC already. For projects of this nature it is necessary to consider a longer time horizon. For this reason, scenarios one and two attempt to estimate costs and revenue to the year 2005, given different consumption growth assumptions.

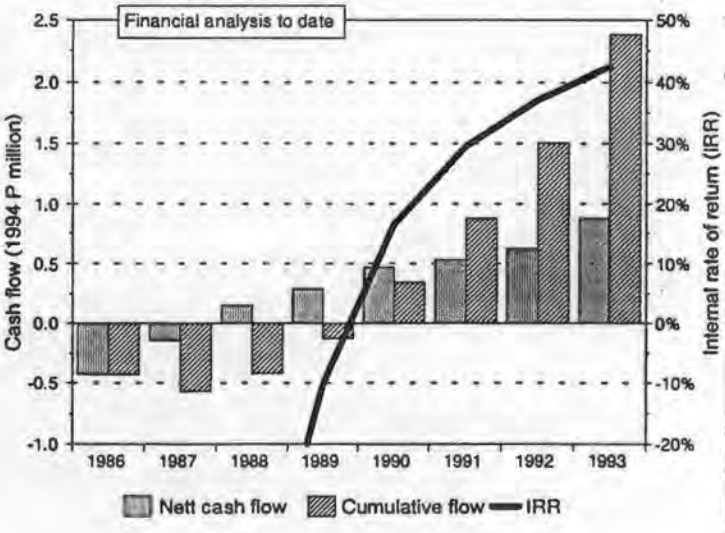

Figure 5.10: Financial analysis - Cash flow & IRR: 1986 - 1993

Scenario one

The graphs below present the costs and revenue for the entire 20 year period from 1986 to 2005. Also presented are the nett and cumulative cash flows and the internal rate of return. The nett present value of the project, assuming a discount rate of 6% is P6.7 million (in 1994 terms). The internal rate of return over the 20 year period is 50%.

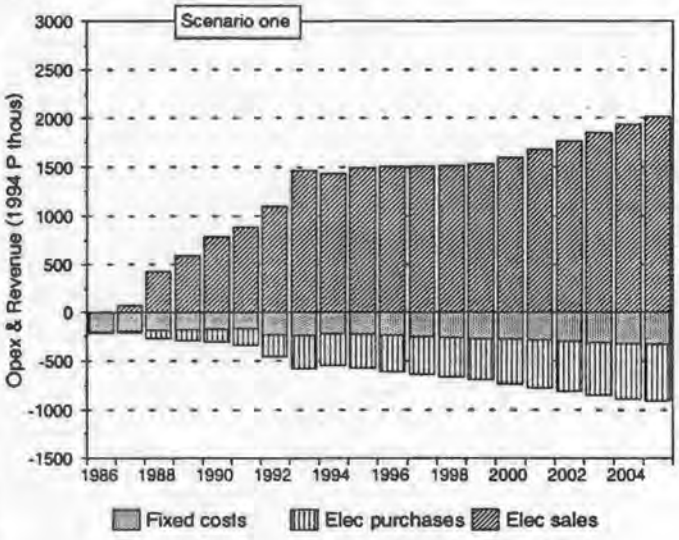

Figure 5.11: Financial analysis - Expenses & revenue - scenario one

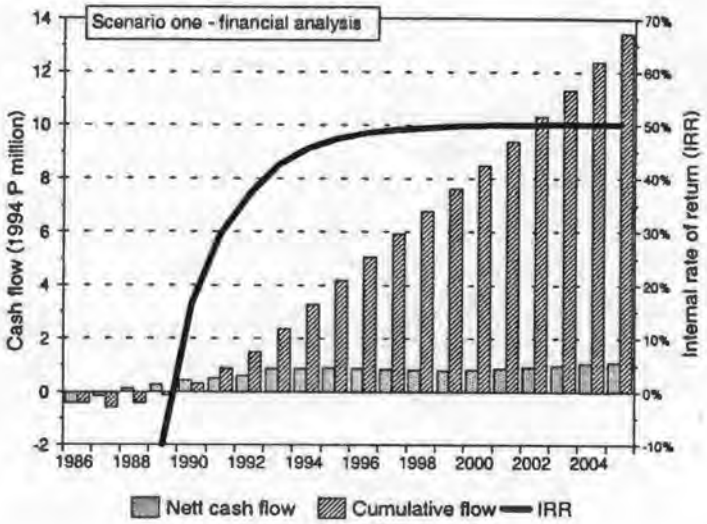

Figure 5.12: Financial analysis - Cash flow & IRR - scenario one

Scenario two

In scenario two, the number of domestic consumers increases considerably. The additional costs include the extension of the reticulation system and increased electricity purchases.

The nett present value of the project under this scenario (over 20 years) is P6.7 million (in 1994 terms) and the internal rate of return is 48% over the twenty year period.

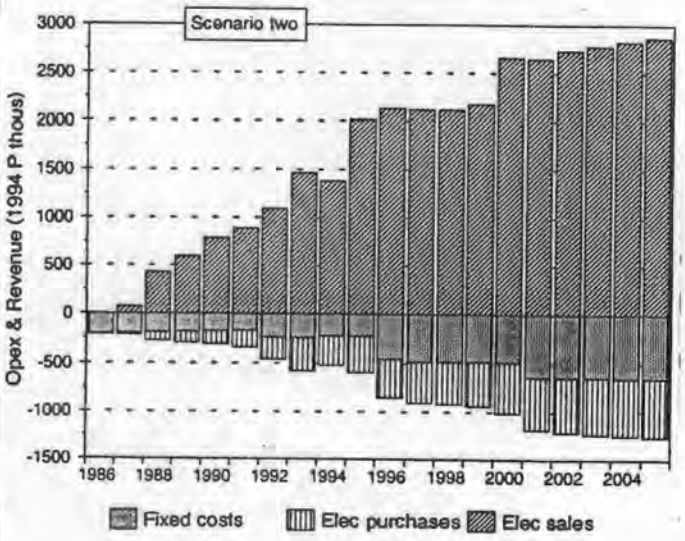

Figure 5.13: Financial analysis - Expenses & revenue - scenario two

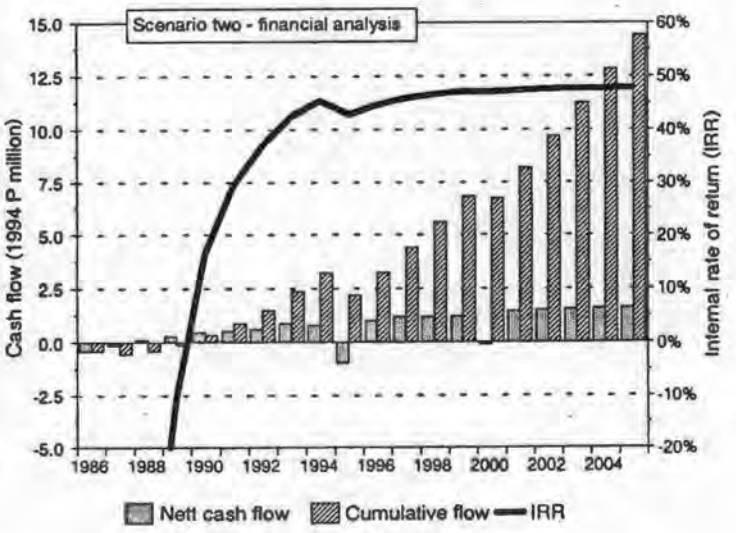

Figure 5.14: Financial analysis - Cash flow & IRR - scenario two

5.5 FINANCIAL ANALYSIS EXCLUDING GRANTS

The financial analysis presented above shows that BPC's return on the Kasane project has been good. However, most of the infrastructure in place has been paid for by grants. It is interesting to calculate the return on the project as if BPC had invested in the distribution network.

There were two sources of grants towards establishing the electricity distribution infrastructure in Kasane/Kazungula. Firstly the CIDA grant established the high voltage link with Zambia as well as the sub-station in Kasane and 30km of medium voltage distribution lines. Secondly the ALSP of the Botswana Government paid for electricity distribution infrastructure in three areas: the Kazungula industrial site; the new Kasane and Kazungula commercial areas; and the new housing development on the Plateau. In addition, the Botswana government contributed 25% of the cost of establishing the underground line to Chobe Game Lodge. The actual amounts are presented in table 5.10.

Table 5.10: Subsidies from SADCC, Botswana Government and ALSP

Source	Grant	in 1994 Pula
SADCC grant in 1986	P5 600 000	P13 600 000
Botswana govt. grant in 1986	P89 500	P217 000
ALSP funds in 1992	P835 000*	P1 100 000
TOTAL		**P14 917 000**

* - estimate based on analysis of distribution maps

The cash flows and internal rate of return for the two projected scenarios are presented in figures 5.15 and 5.16.

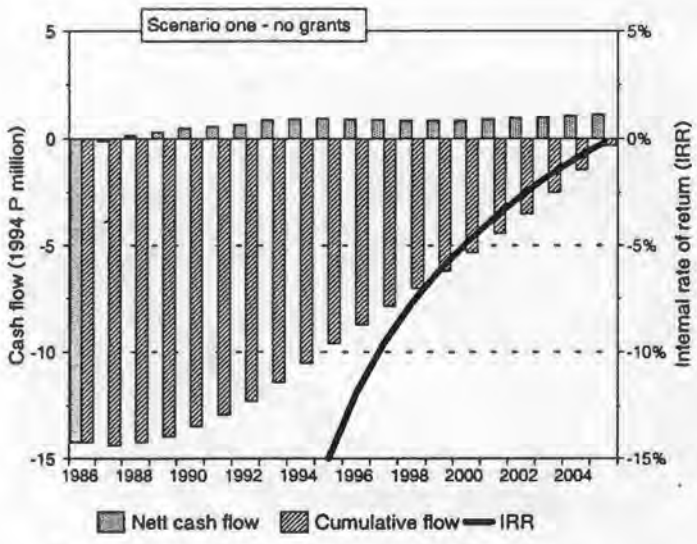

Figure 5.15: Cash flows & IRR as if there were no grants - scenario one

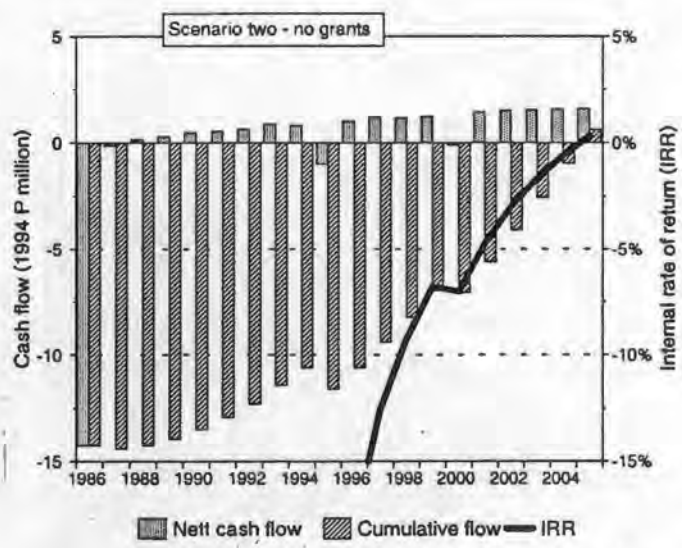

Figure 5.16: Cash flows & IRR as if there were no grants - scenario 2

For scenario one, the cumulative cash flow does not turn positive over the period. The nett present value of the project under this scenario is negative (-P7 million, in 1994 terms, discounted at 6%) and the internal rate of return over the twenty year period would be -0.2%. For scenario two, the cash flow just turns positive in year 20, the nett present value is still negative (-P7 million) and the internal rate of return is 0.3%.

5.6 ECONOMIC ANALYSIS

The financial analysis presents the returns of the project for BPC - the supply utility. For funders and government, it is of interest to establish the overall economic returns of the project, including the real costs of establishing infrastructure and the benefits beyond revenue to the utility.

To adjust the financial analysis to the economic analysis, it is necessary to:

- remove grants to BPC as a source of revenue to reflect the true costs of establishing the infrastructure that grants covered;
- quantify the national savings due to replacing electricity from diesel gensets with grid electricity;
- quantify the consumer surplus as an additional benefit beyond the revenue from electricity sales; and
- attempt to quantify some of the beneficial effects on the local economy.

Subsidies

The subsidies from CIDA and ALSP are removed as in the previous analysis.

Benefit scale factor

The additional benefits which arise from access to electricity include the savings involved in the reduced use of alternative energy sources; and the "consumer surplus" or benefit due to access to improved and additional energy services.

It is possible to encapsulate these benefits into a "benefit scale factor" (BSF) for different categories of consumer. For each case, it is necessary to analyze the utilisation of fuels displaced by gaining access to electricity. The total benefits are then estimated to be the cost of the energy replaced (shadow priced) plus the value of additional useful energy consumed plus the consumer surplus on the additional energy. The last item requires a demand curve, which is assumed to be a straight line (see figure 5.1). The BSF is then defined as the ratio of the total benefit to the revenue from electricity sales.

Having defined the BSF for a consumer, the additional benefit of electricity consumption (beyond the monthly electricity bill paid) is given by the product of the BSF with the electricity bills.

The methodology used to evaluate the benefit scale factor is given by Robinson (1991). The inputs required for the methodology are the quantities of fuels displaced by electricity and the amount of electricity used; the local costs of these fuels; the shadow price of these fuels (taking into account forex considerations, taxes and subsidies) and the conversion efficiency to useful energy.

For households, the survey data was analyzed to reveal the quantities of fuels replaced by electricity. These, together with local prices, subsidies and conversion efficiencies are given in the table below. The calculations produced a benefit scale factor of 1.3 for domestic consumers on current tariffs. This is less than that calculated by Robinson (1991) who found a factor of 3.3 for domestic households. The main difference lies in the fact that unit costs of electricity in Botswana are considerably more expensive than in Zimbabwe (Robinson uses a unit cost of 9c(Zim)/kWh, whereas BPC charges around 27 th/kWh = ±60c(Zim)/kWh). Therefore many of the benefits of improved energy services are already contained in the tariff.

No benefits were calculated for consumers using prepayment meters (under scenario two) since the high tariff precluded any additional benefits beyond the electricity bill.

Table 5.11: Domestic fuel displacement by electricity (an average household)

Fuel	Quantity displaced*	Local cost	Conversion Efficiency
Wood	184 kg/month	P0.31/kg	7%
Gas	8.1 kg/month	P2.60/kg	45%
Paraffin	6.5 l/month	P1.07 /l	40%
Candles	2.3 pkt/month	P2.28 /pkt	---
Car batteries	2 chrgs/month	P1.10 /chrg	65%
Electricity	180 kWh	25.65th/kWh	67%

* Based on household energy use data from the questionnaire survey - electrified vs unelectrified.

A similar exercise was conducted for commercial enterprises where it was assumed that electricity generated by diesel gensets is replaced by grid electricity. A number of businesses in Kasane provided information on their diesel consumption before electricity became available and their current electricity consumption. Using these figures, benefit scale factors could be calculated. The businesses covered included small commercial enterprises, large tourist lodges and agricultural enterprises. For small commercial enterprises that do not pay a demand charge (Business 1), the BSF varied between 1.3 and 1.6. The lower of these values was used. For larger productive enterprises using the tariff which includes a demand charge (Business 2 & 3), a lower BSF of around 1.1 was found.

The following benefit scale factors were used:

- Domestic consumers 1.3
- Business 1 (no demand charge) 1.3
- Business 2 & 3 (with demand charge) 1.1

Beneficial effects on the local economy

The introduction of electricity into the Kasane area has had a number of beneficial effects on the local economy. A number of businesses indicated that they would not have established themselves in Kasane had electricity not been available. Other businesses indicated that their turnover had increased since electrification and indicated that the availability of electricity was an important factor. A few businesses indicated that electricity had not made any substantial difference to their operations.

Although it is clear that developments in Kasane are not only due to the introduction of electricity, at least certain developments have been made possible by electricity. It is difficult to quantify these development effects, although a limited approach is to quantify the number of jobs in enterprises that would not have been present without electricity. One option is to assign the average cost of job creation in rural areas, or a portion thereof, as the benefit. This would be a once-off benefit at the time that the job was created. Another option is to quantify the annual salary bill for these newly created jobs and take a percentage of this amount as the annual, recurring benefit. This latter approach was taken, with a value of 10% being used. Although this figure is somewhat arbitrary, the true value of performing this type of analysis lies in comparing different projects. When it is used in this manner, as long as the methodology used is reasonable, and is consistently applied to each project, the results can give a useful ordering of priorities.

Scenario one

The graphs below present the costs and revenues for the entire 20 year period from 1986 to 2005. Also presented are the nett and cumulative cash flows and the internal rate of return.

The cumulative cash flow turns positive after 16 years (2001). The nett present value of the project, assuming a discount rate of 6% is -P3.5 million (in 1994 terms). The internal rate of return over the 20 year period is 3.4%.

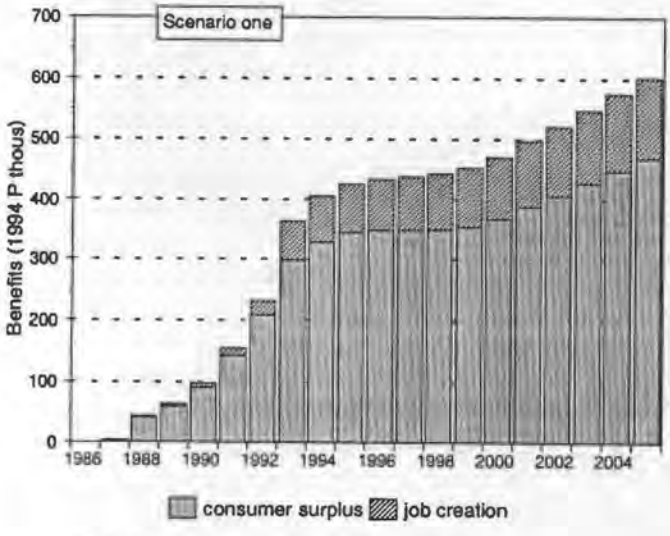

Figure 5.17: Additional benefits - scenario one

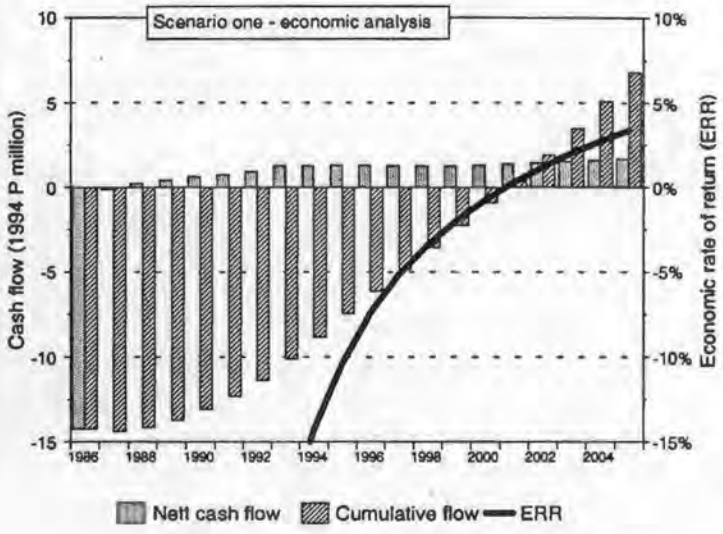

Figure 5.18: Economic analysis - Cash flows & IRR - scenario one

Scenario two

In scenario two, the number of domestic consumers increases considerably. The additional costs include the extension of the reticulation system and increased electricity purchases.

The cumulative cash flow turns positive after 17 (2002) years and the internal rate of return is 3.3%.

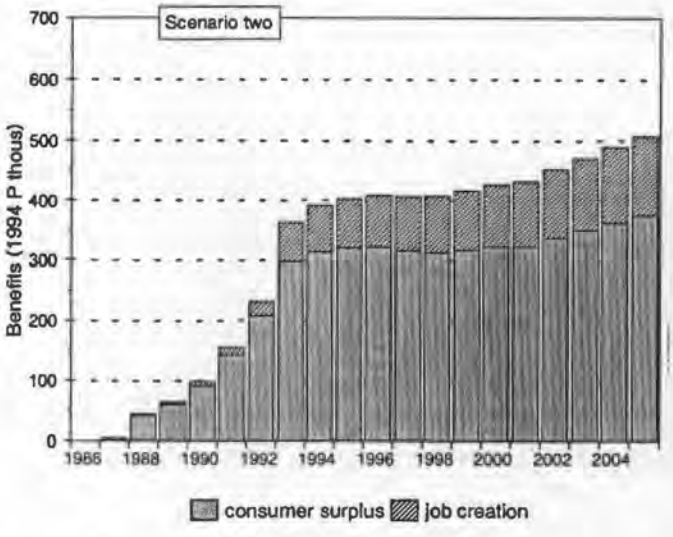

Figure 5.19: Additional benefits - scenario two

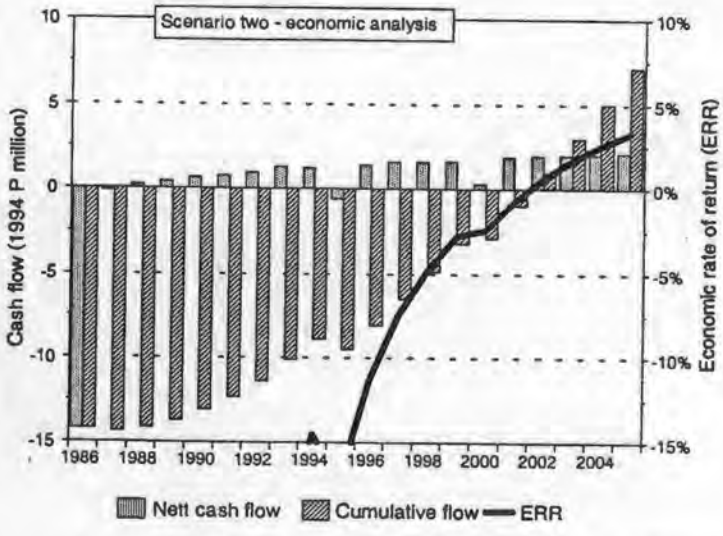

Figure 5.20: Economic analysis: Cash flows & IRR - scenario two

5.7 SENSITIVITY ANALYSES

The construction of the financial and economic analyses is based on both empirical data and a number of assumptions. It is important to investigate the sensitivity of the results to the most important assumptions.

The real discount rate, which discounts future cash flows to their present value, is taken to be 6%. A higher discount would mean that money spent or received now is worth considerably more than future amounts. This would correspond to high interest rates and situations where there are strong competing demands for cash. Conversely, a lower discount rate would value money available now less.

Another important variable is the assumed revenue due to future electricity sales. Revenue will be affected by three variables: the number of consumers; the average rate of consumption; and future tariffs. The two scenarios presented examine the effect of varying the number of domestic consumers. The results presented in figure 5.22 and 5.23 examine the effects of varying the average consumption rate for domestic consumers; and the effect of tariff increases both above and below the rate of inflation, i.e. real increases and decreases in the tariffs. Varying the consumption rate affects both the revenue and the variable costs; varying the tariff affects only revenue.

A third area to examine is the effect of different valuations of the additional benefits of electricity. The analysis presented here examines the effect of varying the benefit scale factor which measures the bulk of the additional benefits.

For the sake of clarity, results are only presented for scenario one.

Discount rate

Figure 5.21 presents the effect of varying the discount rate from 0% to 10% on both the financial and economic analysis.

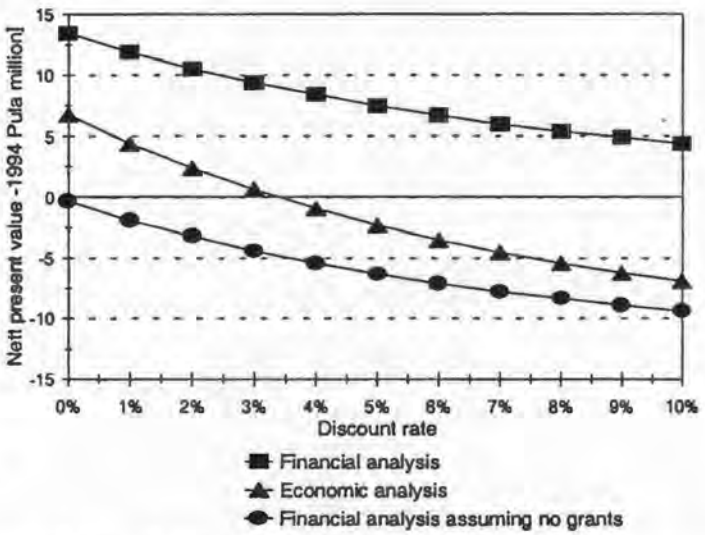

Figure 5.21: Sensitivity to discount rate - scenario one

Consumption rates

New domestic consumers' consumption represents most of the source of future increases in electricity consumption. This variable is also the hardest to predict with confidence. Scenario two assumes an initial consumption of 150kWh/month, increasing at an annual rate of around 8%. This estimate is probably on the conservative side. Monitoring of consumption growth rates in newly electrified low-income areas of South Africa (admittedly urban areas) indicate that within two years the average consumption rate has increased to 250kWh/month (Thorne, 1994). The analysis presented in figure 5.22 examines the effect of increasing the average domestic consumption rate to 350kWh/month.

Tariff increases

Over the past five years, BPC tariff increases have consistently been less than the inflation rate, i.e. there has been a real decline in tariffs. Average increases have been in the region of 8% pa, compared to an inflation rate over the same period of 12% pa. The sensitivity to the real increase or decrease in tariffs is presented in figure 5.23.

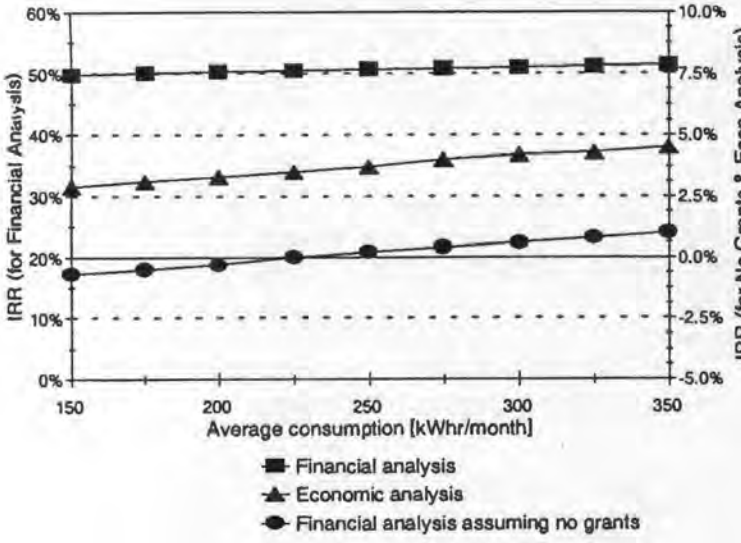

Figure 5.22: Sensitivity to consumption rate scenario one

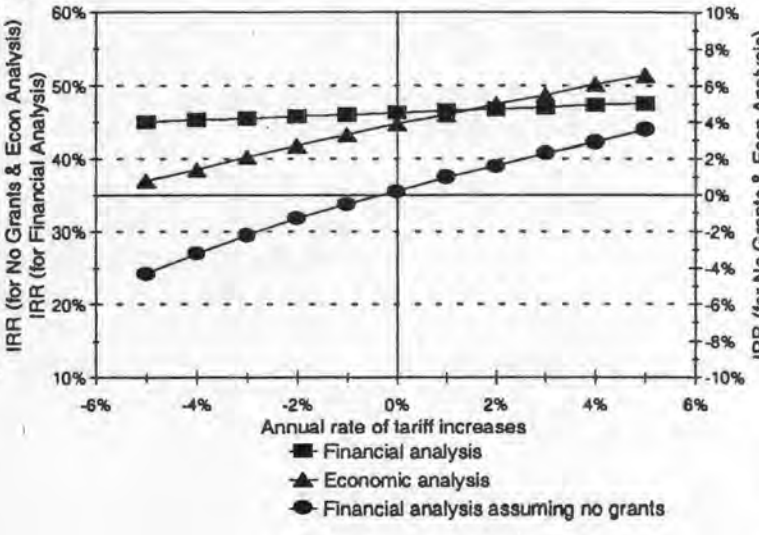

Figure 5.23: Sensitivity to real tariff increases scenario one

Benefit scale factor

The main source of additional benefits quantified in the economic analysis is encapsulated in the benefit scale factor. Analysis of fuel substitution patterns led to an estimate of 1.3 for this factor (except for Business 2 & 3., which was 1.1) This includes three components: the value of displaced energy; the value of additional useful energy consumption; and the consumer surplus attributable to this increase. This does not include less quantifiable aspects such as the improvement in the quality of light; or the convenience of electricity. These considerations make it likely that the BSF is an under-estimate of the true benefit of electricity. The sensitivity to varying the BSF from 1 to 5 is examined in figure 5.24.

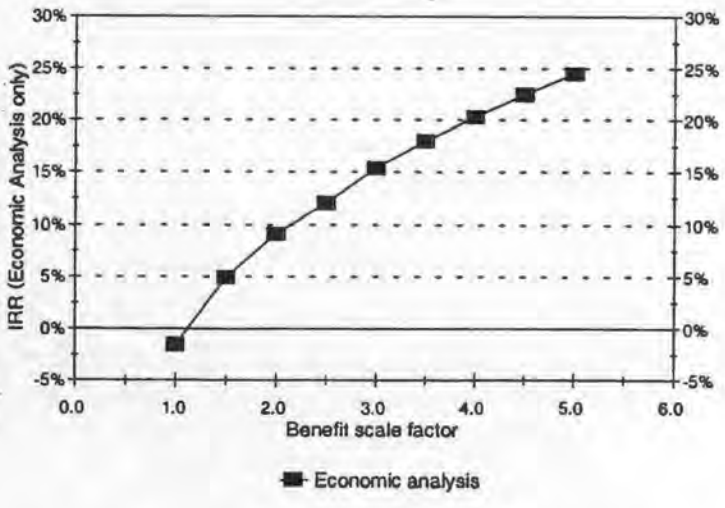

Figure 5.24: Sensitivity to benefit scale factor - scenario one

Level of initial grant

It is unlikely that a similar project would ever again be completely funded by foreign grants. Instead, it is likely that a certain amount of co-funding would be required by local institutions. Figure 5.25 examines the effect of the rate of return to BPC if only a varying proportion of the initial costs were covered by grants. BPC would be expected to finance the remainder.

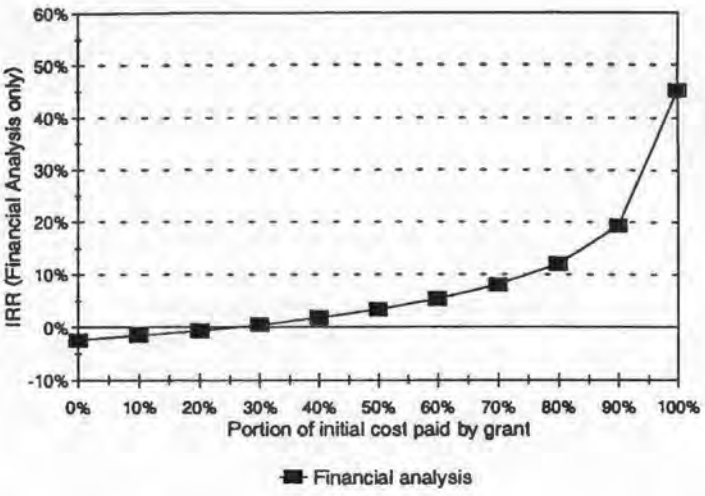

Figure 5.25: Sensitivity to the capital subsidy level - scenario one

5.8 SUMMARY AND DISCUSSION

A summary of the most important results is presented in table 5.12.

Table 5.12: Summary of results

		IRR	NPV
Financial Analysis	1986 to 1993	43%	P1.6 million
	Scenario 1 to 2005	50%	P6.7 million
	Scenario 2 to 2005	48%	P6.7 million
Financial Analysis (excluding grants)	1986 to 1993	-25%	-P12 million
	Scenario 1 to 2005	-0.2%	-P7 million
	Scenario 2 to 2005	0.3%	-P7 million
Economic Analysis	1986 to 1993	-20%	-P11 million
	Scenario 1 to 2005	3.4%	-P3.5 million
	Scenario 2 to 2005	3.3%	-P3.7 million

Financial viability from BPC's view

From BPC's point of view, the electricity supply in Kasane is a profitable exercise. Almost all the capital expenses of establishing the distribution infrastructure were paid for by grants. Connections to the grid have been based on the "user pays" principle. In the Kasane area, private households, businesses and government offices have all paid for connections to be installed. In the Plateau housing development, the ALSP programme paid for reticulation infrastructure and Botswana Housing Corporation, which owns most of the houses, paid for almost all the individual connections. BPC has been exposed to minimal risk in terms of capital outlay.

The internal rate of return which BPC can expect over the 20 year period is high - around 50%. The main reason for this is that the national tariff paid by consumers in this area is not related to the costs of supplying electricity to Kasane, but is based on BPC's long run marginal costs for supplying the entire country. In other words, it is cheaper for BPC to purchase electricity from ZESCO than to generate it within Botswana.

Could BPC have paid for the infrastructure?

The analysis shows that the nett present value of the project would be negative (at a real discount rate of 6%) if BPC had to invest in all the distribution and reticulation infrastructure, i.e. if no grants had been available. It is unlikely therefore that BPC would have been prepared to make the initial investment without the assistance of grants.

If BPC requires a 6% real rate of return, then a grant covering approximately 50% of the original infrastructural costs would have been sufficient for the project to generate this level of return for BPC.

Results using BPC's national cost parameters

A slightly different picture emerges if the analysis uses BPC's national marginal cost of electricity instead of ZESCO's tariff to calculate variable costs of supplying electricity in Kasane. The current marginal cost of each kWh sold is estimated to be about 10 thebe per kWh (this does not include operating costs). If this value is used to calculate the cost to BPC of supplying electricity (excluding fixed costs), the results of the analysis make the investment look less attractive. Table 5.13 presents these results.

Although the financial analysis is not affected much, i.e. BPC retains a high (albeit slightly reduced) internal rate of return, the results with no grants make it clear that it is very unlikely that BPC would have chosen to invest in the original infrastructure provision.

Table 5.13: Summary of results using BPC's national costs of electricity generation

		IRR	NPV
Financial Analysis	1986 to 1993	37%	P1.3 million
	Scenario 1 to 2005	45%	P5 million
	Scenario 2 to 2005	41%	P4 million
Financial Analysis (excluding grants)	1986 to 1993	-27%	-P12 million
	Scenario 1 to 2005	-2.5%	-P9 million
	Scenario 2 to 2005	-3.2%	-P10 million
Economic Analysis	1986 to 1993	-21%	-P11 million
	Scenario 1 to 2005	1.9%	-P5 million
	Scenario 2 to 2005	-0.8%	-P6 million

Were the grants worthwhile?

The question that funders are interested in is whether, from the viewpoint of the regional or national economy, the grants were worthwhile. In other words, do the benefits of the project outweigh the costs? The results of the economic analysis show that, projected over a 20 year period, the IRR is positive (over 3%) and therefore if a discount rate of 6% is considered realistic, the nett present value of the project will be negative. This analysis therefore shows the project to be only marginally economically viable.

It must be stressed, however, that quantification of the benefits of electricity tended to conservative estimates, including only revenue from electricity sales, some benefits as represented in the BSF, and some employment benefits. There are a host of other powerful benefits (such as social benefits due to improved street lighting or hospital facilities, facilitation of water supply, and potential educational benefits) which are not easily included in a quantitative analysis of this nature. The sensitivity analysis to the benefit scale factor shows that the returns increase considerably if a higher value is assumed (a BSF of 1.6 is sufficient to bring real economic returns up to 6%). If a broader range of benefits could be adequately accounted for in such an analysis, the indication is therefore that the economic viability of the project would be more clearly positive.

Another factor which results in reduced financial and economic returns in scenario 2 of this analysis concerns the prepayment meter tariff. This tariff was designed to give a 2.5% real return over 20 years, i.e. from 1994 to 2014. However, the analysis is only undertaken to year 2005, at which time the full returns on the tariff would not yet have been realised.

Optimising the tariff for maximum domestic access

Scenario two proposes that a major initiative is made to improve the access which households have to electricity. The main unelectrified residential areas of Kazungula, SHHA and the SHHA area on the Plateau are all provided with full reticulation and a ready-box and prepayment meter at each site. The initial costs of this investment are assumed to be borne by BPC, but recovered from the consumers over a 20 year period.

A special prepayment meter tariff is assumed to apply to these new customers. This tariff is a simple straight line tariff with the energy charge being comprised of three components: a charge to cover fixed costs; an energy charge as paid by other consumers; and a capital redemption charge to cover the infrastructural costs associated with supplying these new consumers. Assuming a connection cost of P3 000 per household (approximately the national urban average), an average consumption of 200 kWh/month over 20 years, a twenty year pay-back period and an internal rate of return of 2.5%, the tariff is calculated at 38.1 thebe/kWh. This formula implies that over a twenty year period, the new consumers pay for all the costs of supplying them, i.e. there are no direct grants or cross-subsidies. However, BPC's cost of capital is likely to be higher than 2.5%, and so there is a measure of concessionary finance in this tariff. BPC needs to carry the capital cost of this investment until it is repayed via the tariff.

The financial and economic analysis on this scenario shows that the rate of return for BPC is affected only slightly (this is because the tariff is calculated to ensure a 2.5% real rate of return), and that the effect on the economic return of the project is minimal.

However, this tariff may be considered high and it may prove to limit the growth in consumption which is projected in this scenario. In addition there may be political sensitivities to new consumers on prepayment meters paying a tariff that is almost double that which other consumers pay (although it must be remembered that this is because their connection cost is financed, while others had to pay up-front).

There are a number of ways in which the tariff can be optimised, however, and these would need to be explored before such a tariff was implemented. Two of the most important variables to be considered in tariff design include the financing period, and the type of financing.

Concessionary finance or grants may be justifiable to further improve the affordability of the tariff. This could be motivated by the likely economic benefits. In addition, BPC subsidies may be appropriate, as BPC is currently generating a significant surplus out of the Kasane project as a direct result of the original CIDA grant funding, and therefore profits could be partially re-directed to increase local benefits.

If concessionary finance can be arranged, then the tariff surcharge will be reduced. The total loan required to electrify Kazungula, Kasane and the new Plateau SHHA area is in the region of P2.3 million. If this is covered by a 20 year, zero real interest rate loan, then the tariff is likely to be reduced to about 35 t/kWh.

CHAPTER 6

DISCUSSION & RECOMMENDATIONS

CHAPTER 6

DISCUSSION AND RECOMMENDATIONS

6.1 THE SUITABLE CONTEXT FOR RURAL ELECTRIFICATION

Background

The context within which an RE project is carried out is widely regarded as critical for success. Not just any area can be electrified with positive effects. For example, if people are primarily concerned with subsistence, it may often be considered a luxury. The level of disposable income of households needs to have risen to a certain level before people will spend money on electricity supply. In fact, the level of disposable income is often viewed as the most significant single determinant in predicting the success of household electrification. The World Bank has come up with the following set of guidelines which indicate whether the take-up rate will be adequate and whether productive activity will be accelerated by the supply of electricity (Foley, 1992):

- local infrastructure is relatively well developed (particularly roads)
- agricultural output is growing
- productive uses in farms & related industries is growing
- the population density is suitable (large settlement, not too dispersed)
- incomes and standards of living are improving
- there are regional plans for developing the area
- the grid extension distance is not excessive relative to the demand

These guidelines give the picture of an already developing area in many respects, within which electricity can act as a catalyst to development. This in some ways is in contrast to the view that RE can 'cause' development and lift areas out of their dormancy to join the modern world. So productive activity needs to be already in place and then electricity can provide a stimulus to production.

Applicability of the 'suitable context' guidelines to BPC and the Botswana Government

The above guidelines are only partly applicable to BPC electrification projects. This is because BPC generally does not pay for any line extensions. These are usually paid for by customers or the state. Since cost recovery over time is not an issue to BPC, take-up rates are not central to the viability of their operations.

The guidelines are nevertheless applicable with respect to the potential for RE to stimulate production and impact on household welfare (which is obviously related to take-up rate). In effect, they are concerned with the economic viability of projects, which is the motivation for the Botswana Government's support of rural electrification.

The context in the Kasane area

The area has a number of natural advantages which have resulted in a steady economic growth and concurrent population increase (although it is likely that this growth is partly attributable to the massive state spending injections into the local economy in the early '90s). Some of the other important factors which have contributed to the development of the area are:

- its strategic location and pleasant setting for tourists
- its establishment as district administrative and supply centre
- its position on an important north-south trade route
- its strategic position with respect to security
- its central position amongst a number of smaller settlements in the surrounding area
- its forestry resources due to the high rainfall

There is a relatively well established infrastructure largely financed by state projects, which again facilitates further development. Even amongst the poorer settlements in the area, household disposable incomes appear to be higher than for many other rural areas. The general development dynamic evident is also showing no signs of decreasing, as a number of new businesses have recently come into the area, or are planning to establish themselves here. The indications are therefore that the development momentum has surpassed a dependence on injections from the state. In addition, Kasane has been classified as an 'urban' area, which puts it in line for a higher order of state resource allocation. There are very few viable agricultural ventures, partly due to the absence of a ready market for produce. The economic base of the area is, however, not dependent on agriculture.

The area has a substantial business base, partly centred around the tourist industry, which has utilised electricity extensively. Households with electricity have also been able to support a reasonable level of demand due to their adequate incomes, although to date connection charges have excluded most from gaining access to electricity.

Proximity to an existing grid line is also a consideration in evaluating the potential viability of rural electrification projects. Fortunately, in Kasane the connection to the existing Zambian grid was covered by grant funding. Otherwise this could have been a major constraint, as the project is likely to have been financially unviable.

Amongst the major beneficiaries of electricity have been the state departments and institutions, most businesses (except small ones), and the connected households. The experience in this electrification project supports the World Bank indicators to a large extent. Basically, Kasane is a relatively large and growing settlement with a sound economic base, and the impact of electricity has been found to be an important contributing factor to development.

6.2 FINANCIAL AND ECONOMIC VIABILITY OF THE KASANE PROJECT

BPC clearly makes a substantial profit from their operations in Kasane, despite the fact that their fixed overheads per customer are probably higher here than in other areas. The two main reasons for this are firstly the distribution infrastructure was paid for by grants, and secondly the cost of purchasing electricity from ZESCO is cheaper than BPC's bulk supply costs.

If BPC did not have access to grant funding, but instead had to finance the original infrastructure costs, the Kasane project is unlikely to have been financially successful for them. However, the financial analysis shows that over the long term (at least 20 years), BPC's internal rate of return is approaching positive. Considering the likely economic benefits of electrification, the project may thus still have been considered feasible.

If the experience of Kasane is to inform electrification projects elsewhere, it is necessary to consider the financial implications of not having access to cheap imported electricity. If the cost of electricity to BPC is closer to their true generation and transmission costs, then the viability of the project deteriorates. If capital infrastructure is covered by grants, BPC would still realise a healthy return. If however, BPC had to finance all these costs itself, the internal rate of return on the project would be negative.

The economic analysis of the project shows that for the case of Kasane, the project is marginally worthwhile. However, the benefits quantified in the analysis are tended to be conservative, and if other social benefits are included in the evaluation, the economic viability of electrification is likely to be more clearly positive. In the scenario proposing improved access to electricity, the return on the project is reduced, but only by a small margin (this is partly because the tariff used in this scenario was designed to provide returns over a longer period than was covered by the analysis). This fact, if considered in conjunction with the unquantified benefits of electricity, indicates that a case can be made for the promotion of greater domestic access to electricity.

The validity of a cost-benefit analysis

It must be kept in mind that the financial and economic analyses are highly dependent on a number of assumptions such as the discount rate and the economic benefits quantified. If the state considers a 6% real discount rate feasible for such projects (this rate was used in the financial & economic analyses) and the quantification of economic benefits are accepted as reasonable, then the conclusions of the analysis can be accepted at face value. This is probably not wise, however, as discount rate is partly a function of state priorities, and it is difficult to capture the true benefits of electrification in a quantitative economic analysis. Probably the most important point is to be consistent in evaluating the financial and economic viability of different projects, and on this basis resources can be rationally distributed.

6.3 THE KASANE/KAZUNGULA PROJECT IN RELATION TO BOTSWANA'S ENERGY POLICY

Some of the major thrusts of the national energy policy relate to the encouragement of manufacturing and improving access to all fuels, including electricity. Specific strategies include designing tariffs which facilitate electricity use by industry, and improving household access to electricity via the reduction in connection payments and full reticulation of newly developed areas.

Encouraging of manufacture & other businesses

Manufacturing in the Kasane area is minimal, and is likely to remain as such due to the remoteness of the area and the lack of ready markets. Electricity has therefore had little impact here in the face of these more powerful constraints. Other commercial ventures have, however, benefitted from electricity use, and the economic growth in the area directly attributable to electrification is estimated at about 10% (both job creation and turnover). This includes both the expansion of existing businesses and the influx of new ventures.

As a part of the state's policy to encourage industrial development, the commercial and industrial sites at Kasane and Kazungula were established (within the ALSP projects). These include the provision of power to the sites (although businesses still must pay the connection fee). So far, one or two years after completion, this strategy has been only marginally successful. The sites are largely vacant, and the highest occupancy rate is in the Kazungula industrial area, where about 11% of the sites are being utilised. Reasons for the low occupancy rates include

administrative problems, service installation quality problems, potentially inappropriate allocation of sites[1], lack of demand, and lack of private capital for new construction projects.

The tariffs currently applicable to businesses do not appear to have been a serious constraint on expansion of larger businesses, although there is clearly some discontentment with these tariffs. Areas where tariffs could be more 'user-friendly' include making connection costs more accessible to small businesses, considering alternative demand tariffs for variable peak load users, and, specifically for the study area, tariffs to facilitate the use of security lighting (time-of-use tariffs may be appropriate here).

Household access

Excluding connections which were paid for by the state or by BHC, there are very few households connected to electricity. No RCS projects have been implemented here either, partly because households generally are not aware of this scheme, because the process is relatively difficult to implement and demands significant attention from BPC to manage, and also because the up-front payments required by this scheme are still out of the reach of many households.

The current state policy to fully reticulate new housing developments will make a significant contribution to the accessibility of electricity, and will mean that the maximum payment per household will be the connection fee (no grid extension will be required). It is nevertheless likely that this payment will still exclude a significant number of households from connecting, and therefore further measures in this regard may be necessary if the accessibility issue is to be effectively addressed.

Although the overall domestic connection rate in the Kasane/Kazungula area is not insignificant (42%), there has been a notable shortcoming with respect to household access to electricity: where people have had to rely on their own resources to connect, they have generally not been able to do it. The need for strategies to improve domestic access to electricity is thus illustrated. It is likely that this will require more than presently offered by the RCS or by full reticulation (but not connection) of unelectrified residential areas.

As the national energy policy has identified accessible connection costs as a focus area, and BPC is currently engaged in investigating tariffs to improve accessibility, it seems likely that connection rates in Kasane/Kazungula and other rural areas will increase significantly in future.

6.4 IMPLICATIONS FOR THE VIABILITY OF RURAL ELECTRIFICATION PROJECTS ELSEWHERE

Table 6.1 shows how the Kasane/Kazungula electrification project utilisation of electricity compares with that regarded by BPC as typical for rural areas. It can be seen that household connections are higher than the BPC expectation, but only marginally so where they have had to pay for connection themselves (SHHA and Kazungula). Business and government department connection rates are also much higher, with the exception of small businesses, where connection costs are again often unaffordable. The BPC estimates may be based on more remote areas where businesses are in general smaller, as opposed to Kasane, which has a relatively large business sector and many government departments which act as district HQs. In general, therefore, the experience with the Kasane/Kazungula project is not substantially different to BPC experience elsewhere.

[1] Plots were not necessarily allocated to persons who had the means and intention to utilise them in the near future.

Table 6.1: Electrification in the Kasane area compared with BPC experience elsewhere

	number	number connected	% connected	BPC guidelines (experience)*
Households (All areas)	1026	433	42 %	2 %
SHHA & Kazung only	607	20	3 %	
Large businesses	46	42	91 %	50 %
Small businesses	33	3	9 %	
Government depts.	45	42	93 %	50 %

* - based on BPC experience in rural areas

The Kasane project indicates that the following categories of households, businesses and institutions may be expected to connect:

- wealthier households (top few percent of the population). Few of these will connect up immediately, but numbers can be expected to increase over time.
- all lodges and hotels. These are likely to connect immediately.
- all retailers, although not necessarily immediately.
- all other relatively large businesses, which are likely to connect soon after electricity becomes available.
- most government departments (although the Kasane experience is admittedly biased because of the predominance of larger district HQs, which may be atypical of other areas - even here, connection of departments was slow, and occurred over a period of a few years).
- large agricultural operations

The following are unlikely to connect with current tariff and connection policy:

- most households
- small businesses
- small farmers

The project also provides generalisable indications of where benefits are to be expected from those that connect, which in turn points to the economic viability of the project. The fewer potential consumers there are in an area, the lower will be the utilisation, benefit, and viability of rural electrification. The major beneficiaries of the electricity supply are likely to be the following:

- lodges/hotels (cold storage, geysers, cooling appliances etc)
- retailers, bars & restaurants (refrigeration, baking, tills, lights)
- garages (petrol pumps, workshops)
- other workshops (carpentry, welding etc)
- all offices (faxes, photocopiers, lights etc)
- large agricultural operations (water pumping, cold storage etc)
- government departments (particularly those using heavier equipment in workshops or for water pumping etc)
- hospitals and clinics
- wealthier households
- schools (if they are to be electrified)

In the case of government offices, schools or other state institutions, the benefits are also largely dependent on funds available for the purchasing of electrical appliances.

If connection fees become more affordable

In the advent of more accessible connection policies, however, small businesses and households can be expected to connect to a larger degree (dependent on the nature of the connection fee of course). Household impact then becomes a significant benefit of electrification, and may result in greater financial returns as well. Impact on households is also expected to be greater where adequate disposable income exists for them to purchase appliances and utilise electricity more fully. Households which will utilise electricity significantly are often already spending significant amounts on alternative fuels, including paraffin, batteries, and gas. Experience indicates that where fuel use is very traditional, and energy expenditure minimal, electricity use is more likely to be limited, resulting in high infrastructural costs with little resulting benefits.

General indications of RE viability

In some cases, it may be clear that RE will be an economically sound investment, for example in a relatively high population density area close to an existing grid, which has a sound and developing business sector. In most cases, however, the choice and prioritisation of settlements for RE will be less clear. The final prioritisation can only consistently be made via a financial and economic cost-benefit analysis. The economic analysis, although limited, can quantify the benefits of electrification such that they reflect state priorities (e.g. business growth or domestic welfare benefits), and discount rates can also be tailored according to the appropriate 'social opportunity cost' of money considered relevant by the state.

An assessment of the potential benefits of RE, and also expected revenue, could include the following:

1. Assessment of likely customers - the businesses or other establishments that are likely to benefit from electricity use, keeping in mind that certain operations will utilise electrical equipment more than others (some indications of the extent to which electricity will be used by different operations may be found in this report).
2. Assessment of household disposable income or energy expenditure - this provides an indication of likely utilisation level and therefore benefits to households
3. Assessment of settlement size in relation to the capital expenditure needed to supply the area - smaller settlements demand higher capital investment for smaller returns, particularly if they are far from the existing grid.
4. An assessment of potential substitution of existing energy sources such as gensets for businesses, or paraffin and batteries for households (indications of possible changes in household energy use may be found in this report)
5. An assessment of potential for agricultural applications of electricity (larger commercial farms are likely to be important users, while small farms may have little application for electricity)
6. An assessment of other benefits of electrification (such as fuelwood use substitution and thus potential environmental impacts)
7. An investigation concerning any private or public sector development plans (this gives an indication of whether the area is developing or not)
8. Determine if the population is increasing or decreasing - e.g. moving to the cities (this also gives some idea of the development in the area)

The above assessments should keep in mind any affordability constraints which may prevent households or smaller businesses connecting (e.g. the current high connection fee policy).

Again, the World Bank guidelines listed earlier provide useful general guidelines. Settlements with good prospects for continued growth are the most viable targets for rural electrification. The Kasane area clearly fits this category. A smaller, traditional settlement where household income is relatively low and energy expenditure minimal, and where no sound business sector

is developing, would benefit less, and electrification here may be an unwise investment of resources.

6.5 MAXIMISING THE BENEFITS OF RURAL ELECTRIFICATION

The need for supportive strategies with rural electrification

It is increasingly being realised that it may be necessary to encourage electricity connection and consumption to maximise the economic returns on the project and improve welfare benefits. Common measures considered may be advice concerning electric machinery for production, credit assistance for appliance purchasing, and imaginative tariff structures to make electricity more accessible. Low cost technology may also be effectively used. One aspect of a successful project is a strong focus on the demand side (user needs and means) before implementation. Many utilities have in the past been guilty of focusing on the technical and financial problems of supplying an area rather than 'tailoring' the supply (e.g. via technology, standards, tariffs and broader support measures) to match the local needs.

The need for financing in rural electrification

Most RE schemes need subsidisation initially. They are usually expensive projects per connection due to the long extension distances involved, and are often servicing relatively poor areas, so to receive enough income from the area to recover capital expenditure from the outset is very unusual. As demand increases, the increased energy sales or connection fees paid can start to cover expenditure on the project, but this may take 10 or more years. It is thus important for RE that the utility has the financial buffer to carry such projects for long periods. If initial subsidisation cannot be provided, and cost recovery connection fees or tariffs must be charged from the outset, then the benefits to the area in question may be limited from the start. This has been the case in Kasane with BPCs 'up-front' payment policy, with the majority of households not able to access the benefits of electrification.

Tariffs - improving the accessibility of connection

There are a number of ways in which tariffs can be structured so that sufficient revenue is generated while still encouraging households to connect - particularly the poor (who are usually one of the main target groups for RE). One option that has met with success in South Africa is a tariff which includes a capital recovery component in the kWh charge, and is designed for use with ready-box/prepayment meter technology. This type of tariff is particularly appropriate to RE for a number of reasons:

- capital recovery costs are included in the energy charge, so the poor who use less energy pay a smaller proportion of capital recovery costs
- the connection fee is very affordable, and actual connection costs are recovered by the capital recovery proportion of the charge per kWh
- households pay for electricity in advance, so will not find themselves billed beyond their means (maybe particularly relevant in areas unfamiliar with electricity).

An important prerequisite for this tariff to be affordable is that capital costs are recovered over as long a period as possible - at least 10 years, preferably more. This again points to the critical importance of long-term low-interest financing in improving the accessibility of electricity. The section 'Optimising the tariff for maximum domestic access' in the cost-benefit analysis chapter illustrates the importance of long repayment periods and low interest rate loans on tariff affordability.

Scenario 2 of the cost-benefit analyses, which includes such a tariff, shows that the financial and economic returns on the project can be expected to be minimally affected if the tariff were implemented, particularly if returns are analyzed over the full 20 year period for which the tariff

has been designed. The implication is that BPC's returns would be only slightly reduced and that more households could be benefitting. The tariff used in scenario 2 was, however, largely for demonstration purposes, and included a number of assumptions: it assumed 13% technical and non-technical losses, 80% household connection rate, 20 year full capital repayment period, an average demand of 200kWh/month over 20 years for new users, and 2.5% real interest rate requirement. If such a tariff was developed, these assumptions would need to be further explored. It is important that such a tariff be optimised with respect to affordability, capital repayment period, and interest rates. Concessionary financing and long repayment periods can make a significant difference to the tariff.

BPC is currently engaged in examining tariffs with a view to improving electricity accessibility.

Technology

There are a range of technology options which can be used to supply rural communities - both for distribution and within the household - which can reduce project costs and thus result in lower capital recovery tariffs. Grid extension technology choices include conventional 3-phase, single phase, and SWER, any of which may be suited to RE depending on the area characteristics (of course single phase and SWER do not easily allow for the use of 3-phase motors, which are central to electricity use in many productive activities). Innovative reticulation technologies can also be considered. Depending on the area settlement pattern, it can be more economical to reticulate with intermediate voltage (1kV for example) to reduce losses (this may also reduce pilfering where it is a problem), and place transformers at strategic points from which 400V is tapped. Within households, appropriate technology options can also reduce connection costs significantly. Ready-boxes and surface mounted cabling may be used in place of conventional and expensive full house wiring. Further cost saving techniques which may be appropriate in some settlements include installing lower capacity supplies to households (5 amp for example), which is often sufficient for households for a few years at least, and allows transformer sizes (and thus costs) to be reduced. In later years, transformers can be upgraded as necessary, which is not a costly operation.

BPC already utilises many of the most important low-cost technologies such as ABC cabling, airdac house connecting cable, and prepayment meter/ready-box systems. The latter have the significant advantage that they are able to be used in any house type - be it mud, reed or brick, and therefore are also an essential part of improving accessibility. Surface mounted cabling ('surfix') is also becoming accepted practice in place of the more expensive conventional house-wiring.

There may be further scope for BPC to explore the use of intermediate voltage technologies for reducing costs, although this is often more applicable to lower density settlements.

Marketing & information dissemination

Customer services are increasingly recognised as being important to maximise the benefits of rural electrification projects. The Kasane project is an example where customer services have not been given a high priority, partly due to the technical focus of the BPC depot (some of the problems which have arisen as a result are discussed under 'Summary of problem areas identified'). It is likely that greater marketing and a more end-user focused approach would have increased the benefit to the area. It should, however, be noted that BPC mentioned plans to establish a revenue and commercial office in the area, which would be able to address user needs and queries more effectively. Such a measure would also allow BPC to be more in touch with local needs, and provide feedback to head-office concerning appropriate strategies to improve the effectiveness of supply to such areas. Remaining in touch with consumers in remote areas often requires specific attention if it is not to be ignored.

Another measure which has been effective in other areas with regard to increasing both electricity demand and household benefits is the cheap supply of certain appliances on connection. In some parts of South Africa, Eskom provides new consumers with the option of purchasing an iron, a kettle and a hotplate on connection. Eskom bulk purchases these, and thus prices are very affordable.

A further step which may be effective in increasing domestic connections in rural areas is to simplify the application and connection procedures. Some rural households may find the existing system quite alienating.

Electricity's role in an integrated development programme

Factors affecting development are diverse and complex, and electricity access often fulfils a supportive function rather than 'leading' development. Electrification should therefore preferably be undertaken within a broader development strategy if impacts are to be maximised. The electrification of the Kasane area illustrates this in a number of ways:

State departments and institutions - although electricity was available from the start, several departments only received funds to connect years afterwards. Without the allocation of funds coinciding with electrification, therefore, the impacts are delayed and reduced.

Education - while lights facilitate adult education in the evenings, without the organisational backup to initiate and run classes, the benefits are zero.

Industrial growth - electricity is likely to have little stimulus on the development of a local manufacturing sector in Kasane due to other strong constraints on such ventures (limited raw materials, no local markets, inadequate transport facilities etc).

Theft - although there is potential for electricity to have greater impact on local security, this has not been realised due to the cost implications of running security lights and lack of funds to install street lights in important areas.

Small farmers - for small farmers to benefit from electricity, principally for water pumping, not only would connection costs need to be affordable, but technical advice and equipment would also need to be accessible.

Large scale farms - Chobe Farms has electric cold rooms which have facilitated the efficient harvesting of produce, but without a suitable market these are of little use.

Tariffs - the Kasane project shows that bringing electricity to an area is not sufficient in itself, but tariffs and connection costs need to be designed with users in mind if impacts area to be maximised.

The ALSP has, to some extent included electrification in a more integrated strategy to develop businesses in the area, although with limited impact to date. The programme not only provided land, but also water, roads, streetlights and electricity.

The electrification of the Kasane area can be seen as an intervention in keeping with the 'growth' approach to planning. With this approach, economic growth is the focus. A 'development' approach would have a greater focus on spreading the benefits, particularly amongst the poorer households. These approaches should be balanced in an integrated strategy. The Kasane electrification project has had little emphasis on 'development'.

6.6 SUBSIDISATION OF RE

Financial incentives can be important for encouraging effective operation within utilities, and therefore subsidies should be structured such that they do not interfere with the utilities' incentives to expand its customer base, or explore more cost-effective technologies for reticulation, distribution or connection. One way in which subsidies or grants can be applied is to target capital at specific aspects of a project which will then make it financially viable for the utility to electrify further. This was done in the Kasane/Kazungula area with the CIDA grant, which provided the HV feeder and MV backbone from which the network could be extended. To electrify the remaining unconnected areas in Kasane an Kazungula appears to be financially viable, as the cost-benefit analysis indicates that this could be done on a cost recovery basis, provided connection costs are made more accessible and are recovered over an extended period. The application of subsidies to reticulate these areas is therefore less clearly appropriate.

The impact of the CIDA grant

The nett effect of the CIDA grant has been significant, with far reaching benefits to most of the larger businesses, the public sector and a significant proportion (42%) of the households. The economic analysis, considered in conjunction with less quantifiable benefits of electrification, indicates that it has been a worthwhile investment of resources. BPC has been shown to be making a profit from this area already, and this profit is likely to increase significantly in future years. Their assets have also been increased by the addition of the local grid infrastructure.

From CIDA's point of view, the success obviously depends on their initial (unspecified) objectives. In terms of economic growth goals, the project may be considered a success. If development goals are considered, however, the success of the project has only been partial, as the needs of the poorer households and small businesses, which are both important developmental targets, have not in general been met.

6.7 SUMMARY OF MAIN CONCLUSIONS

Impact of the Kasane/Kazungula electrification project

The benefits

- Most businesses have connected to electricity, and are utilising it extensively. The benefits to the private sector are significant, and it is estimated that this sector has grown by about 10% specifically due to electrification. One of the main reasons for this development is the removal of capacity limits imposed by generators, reduced cost and improved convenience of grid electricity, and ability to utilise a greater range of appliances. Increased refrigeration capacity, workshop equipment, office appliances and security lighting are some of the areas where the most significant benefits have occurred.

- Almost all state departments have connected to grid electricity, and are using it extensively. The use of office appliances, cooling equipment and lights are amongst the most important applications of electricity. Also, some departments were previously using gensets, and thus are benefitting from the reduced cost, greater capacity and improved convenience of grid power. The level of impact for state departments is related to the availability of funds for appliance purchases.

- A significant proportion of houses (42%) have been connected to grid electricity. This connection rate is higher than is found in many rural areas. These houses are experiencing benefits in terms of improved convenience, reduced expenditure, access to a greater range of modern appliances, improved lighting quality, and possibly improved health, partly due to the ability to refrigerate fresh produce. These households did not, in general, have to pay for their own connection.

- Chobe Farms, the only large commercial farming operation in the area, is benefitting from the use of electricity, as it facilitates more efficient irrigation and harvesting. Waste may also be reduced.

- Community facilities such as hospitals and schools have also benefitted from electricity, but to varying degrees. The increased ability to work at night is one of the major benefits for the hospital, while the school that is connected enjoys proper lighting and the use of other educational and administrative appliances. Community night-time activities have also been stimulated by electric lighting, such as recreation (bars, restaurants) and free movement due to street lighting in some areas.

Failure to impact

- Benefits of electricity have largely bypassed the majority of households (58%), who cannot afford the connection fee. They remain without adequate lighting and dependent on inconvenient and more expensive energy carriers. This is probably the most significant shortcoming of the electrification project. Farmworker and other business staff accommodation are also often amongst those not benefitting from electrification.

- Most small businesses have also not been able to afford the connection fee, in spite of some clear productivity benefits which would result.

- Small farmers have also not been able to afford to connect, although electricity is not one of their priorities.

- A few state departments still await the approval of funds to connect, and are sometimes severely hampered by the absence of electricity. The most notable of these is the CTO, which is running a workshop without electricity.

- The impact of electricity on businesses and agriculture has also been restricted to some extent by the tariffs. Some business are not utilising security lights because electricity costs are perceived to be too high, while those with seasonal loads are particularly disadvantaged by the structure of the 'Business 2' demand tariff. Water pumping charges at Chobe Farms are also considered excessive.

- Impact on women has also been minimal, as almost all poorer households and small farmers have no electricity, and it is in these areas that women often are burdened the most with daily subsistence tasks.

Effect on socio-economic disparities & adverse impacts

- Electricity is generally only used by the wealthier households, and has therefore served to increase the disparities between different socio-economic groups in the study area. This is illustrated amongst government employees, where the Permanent and Pensionable (skilled) employees have benefitted from electricity, while the impact on the Industrial class (unskilled) employees has been low.

- The adverse environmental impact of electrification has been low, and is mainly limited to the cutting down of some trees during the construction of electricity lines.

Financial and economic viability of the Kasane project

- The project is financially viable for BPC, and they are already making a profit. This profit is expected to grow significantly in future years.

- BPC would probably not have undertaken the project without CIDA support, as it is unlikely to have been financially feasible.

- The project is expected to result in a positive economic return over the longer term, even if conservative benefits are assumed, as was done in this report. The CIDA investment was thus worthwhile, even though the poorer households have been largely excluded from the benefits.

- If a 'low connection cost, longer-term capital recovery' tariff was applied to the presently unelectrified houses, indications are that adverse effects on the financial viability of the project would be negligible, and BPC's profits would be affected minimally. The indication is that this is justifiable from a both a business and development viewpoint.

Recommendations to maximise the benefits of electrification

- A 'low connection cost, longer-term capital recovery' tariff, with capital redemption included in the energy charge, should be developed and instituted, and all presently unconnected households supplied with electricity on this tariff. The tariff will need to be carefully designed, however, optimising it with respect to affordability, repayment period and financing interest rate. It should be noted that BPC is currently examining the question of tariffs to increase electricity accessibility.

- Pre-payment meter and ready-box technology should be used in connecting these households, except where full housewiring is preferred (it is now standard practice for BPC to use all of these technologies).

- BPC should establish a customer services facility in the Kasane area. This will allow queries to be answered, misunderstandings to be addressed, active marketing to be undertaken, and feedback to head-office on the needs of customers to be provided.

- The feasibility of using other low-cost distribution or reticulation technologies should be explored, including load-limited (e.g. 5 amp), intermediate voltage, and single-phase supplies.

- The potential to customise tariffs to facilitate the use of security lights and water pumps should be investigated. The structure of the 'Business 2' demand tariff should also be reviewed, as it is particularly harsh on customers whose load varies seasonally.

Policy implications of the Kasane electrification project

- Rural electrification is unlikely to cause development in itself, but it can play a significant role in accelerating development if it is applied in a suitable context. If the connection cost is affordable, one of the most important factors affecting the uptake rate of an RE project is the level of disposable income in a settlement. Signs that the area is already developing (production increasing, incomes rising etc.) are also promising indicators that electricity will be well utilised and thus impact favourably on an area.

- Much of the reason for the favourable impact of electricity on the Kasane area was due to the significant business sector, strong state presence, and general development taking place in the area due to its strategic situation on a trade route and in an attractive tourist area. This is atypical of much of rural Southern Africa.

- The application of RE in smaller, traditional settlements, where no sound business base exists and neither population nor incomes are increasing is unlikely to be viable.

- The Kasane/Kazungula project indicates that RE does justify subsidies in certain areas, as the economic benefits can be significant. In order to establish the scale of subsidy justifiable, however, a cost-benefit analysis will need to be done which includes discount rates and benefit weightings which reflect national priorities.

- It is essential to utilise affordable tariffs with minimum connection costs and long-term capital recovery components if impact on households is to be significant. This requires that capital costs be financed over as long a period as possible, and at favourable interest rates.

- The CIDA grant has been a success in terms of economic growth goals. A relatively high percentage of houses have also been connected to electricity, although the majority still remain unconnected. The poor in particular, who are an important developmental focus, are largely unconnected, and so have usually not benefitted directly. The project has therefore only been a partial success with respect to developmental goals. If widespread access is an important objective of such grants, then further measures may need to be taken to ensure that this happens. In the case of Kasane, this could have been achieved by direct CIDA involvement in reticulating and connecting households, or by BPC, using suitable tariffs and technology. The latter approach is preferable, as it can be a financially viable undertaking, and therefore would fall within the utility's charge.

- Support strategies (information dissemination, marketing, appliance purchase schemes) should be considered with RE projects, as they can increase the rate of connection and consumption, and thus improve the economic viability of the scheme. In general, RE

projects will benefit by being approached from the future users' perspective (i.e. looking at their needs and means), rather than concentrating on the technical and financial aspects of supply.

- Accessible tariffs and thus maximum household utilisation of electricity are also essential if benefits are to be felt by women, who are often principally belaboured with the daily domestic subsistence chores.

- If electrification is to address wood scarcity problems, it is of added importance that electricity tariffs are made affordable, as poorer households often utilise wood most extensively. Electricity may in any case not have a significant impact on wood scarcity on a national level, as settlements in which wood use is predominant may also be those where RE is least viable.

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APPENDICES

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APPENDIX A: METHODOLOGY

The project team

The project team consisted of the following personnel from the consultants:

Project leader - overall responsibility for the project.
Project co-ordinator - co-ordinate all aspects of project implementation- including fieldwork administration and liaison, and undertake information processing, synthesis and report production.
Social and environmental expert - involved in fieldwork, information analysis and report writing relevant to social and environmental aspects of project.
Economist - to provide key inputs concerning the economic aspects of the project, including the cost-benefit analysis.
Cost-benefit researcher - to assist in various aspects of the project, but mainly with the cost-benefit analysis.

In addition, the following staff from the Ministry of Mineral Resources and Water Affairs, Energy Affairs Division were central to the project fieldwork:

Senior Energy Officer - co-ordinate logistical support, liaison with state and private sector personnel throughout project, general fieldwork assistance and MMRWA team management.
Energy Officer - assist in logistical support, liaison with government and private sector, and to undertake fieldwork.
Enumerators (x3) - questionnaire enumeration

Initial planning trip

Before the workplan for project implementation was drafted, a planning visit to the study area (via Gaborone) was undertaken.

The visit to the Kasane area (3 days) involved preliminary rural appraisal, energy supply side information gathering, and secondary data sourcing. Scoping exercises identified different social groupings in the area. Commercial, industrial, institutional and household settlement characteristics were also examined, and an overview of the types and number of businesses obtained. Interviews with some key personnel were undertaken, including the area BPC official, state officials, tribal heads, shopkeepers, a school teacher and tourist lodge owners. Informal discussions with residents were also held. Basic fuel use characteristics were observed and some supply sources identified. Information on local electricity connection policies and tariffs were also obtained. Where available, relevant documents and maps were collected.

In Gaborone (1 day), meetings with the MMRWA Energy Affairs Division staff, BPC and other government officials were held. Further relevant documentation and maps were obtained. Information of connections and consumption in the Kasane area, and also on current rural electrification policy and future plans were obtained from BPC.

Comprehensive fieldwork phase

The bulk of the fieldwork was undertaken during February '94. It involved a questionnaire survey, detailed interviews with government departments, private sector and households, and participatory rural appraisal exercises with residents in some settlements. An appliance purchase questionnaire was also utilised to a limited extent.

The MMRWA Energy Officers were present for the entire duration of the fieldwork phase, and the project co-ordinator was present for all but one week of this phase.

Questionnaire survey

First, the draft questionnaire was piloted in two different residential areas with differing social characteristics. At the same time enumerator training was undertaken. Thereafter, the questionnaire was modified, and the final version printed out. Enumerators worked largely by themselves hereafter. Daily quality checks on completed questionnaires were undertaken. Questionnaire coding and data entry also began during the survey, providing further quality checks. The final questionnaire is given in appendix B.

The questionnaire survey coverage was as follows:

	ACTUAL			ORIGINAL PLAN		
AREA	No. h/holds	No. quest	% sample	No. h/holds	No. quest	% sample
SHHA*	484	77	15.9%	620	80	12.9%
Plateau	215	52	24.2%	105	50	47.6%
Govt & White City	127	35	27.6%	75	25	33.3%
Teachers @ CJSS**	18	5	27.8%	-	-	-
Kazungula	120	29	24.2%	180	40	22.2%
Kazungula farming	3	3	100%	50	25	50.0%
Private river front	16	6	37.5%	20	8	40.0%
TOTALS	**983**	**207**	**21.1%**	**1050**	**228**	**21.7%**

* - Self-Help Housing Agency houses
** - Chobe Junior Secondary School

The differences between planned and actual sample sizes was mainly due to the inaccurate house number estimates used in the planning, which were largely extracted from projections given in the DDP4 document. The percentage sample, however, was effectively the same as planned.

Sampling was done by moving through an area systematically, selecting the number of houses necessary to make up the predetermined sample percentage with a fixed frequency. The necessary sample size for each area was based on the number of households in the area (to obtain the same statistical certainty, a smaller group of households requires a larger percentage sample). Each residential area had similar socio-economic characteristics, and thus by treating each area independently, the sample was effectively stratified according to these characteristics.

Interviews with government departments and private sector

Interviews were undertaken by the project co-ordinator, MMRWA energy officers and the social and environmental expert. In some cases, other team members also assisted. Enumerators were not involved in this part of the project. Questionnaires were initially used to obtain information from both government departments and private businesses. However, it was soon found that these were far too rigid a format to adequately capture information discussed, and therefore an interview guideline form was drafted and used thereafter. These forms are given in appendix B. Lists of interviews conducted are given in appendix C.

Interviews with state departments included key personnel such as senior central administration officers, heads of important government departments, and most other smaller departments. Those omitted were a few of the less significant departments.

Private sector interviews covered the tourist sector (mainly large tourist lodges or safari companies), wholesalers, general dealers, transport companies, restaurants, workshops and a range of other shops (butcher, hair salon, appliance shops, bars, etc). A few of the smaller general dealers and some informal businesses were not covered, but sufficient of these types of operations were included to enable their relevant characteristics to be established.

In addition to structured interviews, a number of less formal interviews were held, which were useful in obtaining information on a range of aspects relevant to the project.

Participatory Rural Appraisal (PRA) exercises

PRA can be an effective tool to access a great range of information from local inhabitants. It assumes that the level of local knowledge on the area is great, and that of the consultants limited, and thus utilises various techniques, often involving group discussions, to tap this knowledge. It also allows the local inhabitants to direct the discussions, and thus can identify needs and priorities more accurately, and can access qualitative information more effectively than questionnaire surveys or more formal interviews.

Two PRA exercises were conducted, both in Kazungula village. This settlement was used partly because the inhabitants are amongst the oldest in the area, and thus depth of knowledge on the area was greater. The community was also more cohesive, making it easier to organise such activities here. Although a number of attempts were made to conduct similar exercises in the SHHA area, residents were too busy, unwilling, or did not arrive at pre-arranged meetings.

Of the two successful PRA exercises, one covered domestic fuel use - focusing on wood use and availability, and the other was a historical time-line - revolving around the history of the Kasane/Kazungula area. The exercises obtained relevant insights into perceptions regarding energy use, developmental problems and settlement history.

Appliance questionnaires

A questionnaire concerning purchase of appliances by electrified households was also circulated. This was not meant to obtain statistically representative information, but rather to give an indication of appliance ownership profiles after electrification, decision making dynamics regarding such purchases, and who utilises the appliances most. In total, 15 were completed.

Secondary information gathering

Reports and other secondary information sources were obtained in both Gaborone and Kasane, and constituted important sources of information for the study. The baseline study was obviously also central to this study. Sources used in this report are given in the project references.

Information processing and analysis

Questionnaire data processing

This data was entered onto a spreadsheet (Quatro-Pro). Thereafter it was imported into *Statgraphics*, a statistical data analysis program, where all data was processed as required for the report. Graphs were generated in Quatro-Pro using the data trends extracted from *Statgraphics*. The full set of processed data is presented appendix D.

Interview data processing

Quantitative data from the interviews (number of employees, electricity bills, turnover, etc) was entered into a spreadsheet for processing and input into the report. Qualitative information was used in the analysis as required.

Main impact evaluation information sources

The main information sources for the impact evaluation were as follows:

- comparison with the baseline study
- impacts stated in interviews and emerging from PRAs
- questionnaires (household and appliance utilisation)
- changes in business expenditure and employment due to electrification
- presence of new businesses due to electrification
- other directly observed impacts

Programme followed

The overall project programme followed was as follows:

Initial planning trip	- mid -1993
Main fieldwork phase	- 31January '94 to 4 March '94
Data processing and analysis	- data entry started during fieldwork - data entry completed in April '94 - processing & analysis undertaken in April '94
Report writing	- March to May '94

APPENDIX B:
INFORMATION GATHERING INSTRUMENTS

QUESTIONNAIRE FOR HOUSEHOLDS

Date..... Enumerator.....

Quest. No: H.....

Name of family..... House number.....

AREA	'White city' (govt)	SHHA	plateau	Kasane low cost houses	Kazungula village	'squatter' area	river front (private)	other .....

HOUSEHOLD MEMBER	M	F	**Occupation** scholar, farm worker, policeman...	**Income** Pensions, remittance wages ...	**Education level** grade 6, university...	**Age** +15 yrs or -15 yrs
Respondent 1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

HOUSE

Who owns the house (family, govmnt, etc)?.....

What is the house made of? | brick/block | zinc | mud | wood | ..... |

Number of buildings in the household?.....

Number of rooms in the household (total for all buildings)?.....

How does the household get water?

Full house plumbing	tap on property	communal tap	OTHER (what).....

VEHICLE

Does the household have a vehicle? | NONE | car | bakkie | truck | other..... |

HISTORY

Did you live in this **AREA** before 1987?

NO	YES

How long has your family been in this **HOUSE**?

less than 1 year	1 or 2 yrs	3 to 5 yrs	6 to 10 yrs	more than 10 yrs

Why did the family move here?.....

Where did the family live before moving here?.....

ENERGY USED		Cost	Quantity used per month, in 10 days, etc	Used for cooking, lighting, heating, radio, TV, ...
electricity				
paraffin				
gas				
candles				
battery	PP/PM 9			
	PP/PM 10			
	torch			
car battery (charging)		(cost per charge)	(charges per mnth)	
petrol for generator				
petrol/diesel for car, bakkie, etc.				
other (e.g. coal) what?:.....				

How much do you think all of this costs you per month? P.....

APPLIANCES

What appliances does the household have?

gas stove/cooker	paraffin stove	iron (**elec**)	TV (colour)
gas fridge	paraffin fridge	kettle (**elec**)	TV (black & white)
gas freezer	paraffin freezer	sewing machine (**elec**)	Hi-fi
gas light	paraffin light	lights (**elec**)	fridge (**elec**)
iron (**not** elec)	kettle (**not** elec)	stove (**elec**)	freezer (**elec**)
other		Power tools.....	
elec kitchen appliances.....			

IF ELECTRICITY IS USED

When did you get electricity?.....

Do you feel that you have benefitted from elec (is life better)? | NO | YES |

How has electricity improved your/your families life?.....

.....

Do you have any problems with electricity? | NO | YES |

What are the problems?.....

.....

Do you think **you spending MORE or LESS money** than before you connected to electricity on energy (lighting, cooking, fridges, ironing etc)?

More	Less	Little change	Dont know

What electrical appliances do you still want to get (in order of preference)?

1	stove/ hotplate	lights	TV	Hifi/ radio	iron	kettle	fridge	freezer	other.....
2	stove/ hotplate	lights	TV	Hifi/ radio	iron	kettle	fridge	freezer	.....
3	stove/ hotplate	lights	TV	Hifi/ radio	iron	kettle	fridge	freezer	.....
4	stove/ hotplate	lights	TV	Hifi/ radio	iron	kettle	fridge	freezer	.....

Where do you get appliances repaired (fridges etc)?.....

IF ELECTRICITY IS NOT USED

Do you want electricity? | NO | YES |

IF YES: Why do you want electricity?.....

.....

Why are you not connected?.....

.....

Say which electric appliances you would buy **first**, **second**, **third** and **fourth**:

1	stove/ hotplate	lights	TV	Hifi/ radio	iron	kettle	fridge	freezer	other.....
2	stove/ hotplate	lights	TV	Hifi/ radio	iron	kettle	fridge	freezer	.....
3	stove/ hotplate	lights	TV	Hifi/ radio	iron	kettle	fridge	freezer	.....
4	stove/ hotplate	lights	TV	Hifi/ radio	iron	kettle	fridge	freezer	.....

What do you think is a fair price to pay for electricity - to connect? P.....

- every month? P.....

WOOD

Do you use wood? | NO | YES |

How often do you **make fire**? | 3xp day | 2xp day | 1xp day | 2 or 3xp week | less |

What wood is the best wood to use (names)?.....

Do you have any problems with getting wood?.....

.....

Do you **collect** your own wood? | NO | YES |

Where do you collect wood?.....

How often do you collect wood?

| every day | 3xp week | 2xp week | 1xp week | 2xp month | 1xp month | sometimes |

How long does it take you to collect wood (hours per trip)?.....

Who in the family collects the wood?.....

Do you **buy** wood? | NO | YES |

How often do you buy wood?

| 2 or more x p week | 1xp week | 2xp month | 1xp month | 1xp 2 months | sometimes |

How much do you spend on wood each time you buy?.....

INFORMAL INCOME

Is anyone in the household involved activities such as **brick-making, sewing, basket-making, fishing** etc **TO SELL**? | NO | YES | what?..... |

What is the income from this (per month/year)? P.....

Is electricity used for this? | NO | YES |

How is it used?.....

EXPENDITURE

What is household money spent on?

ITEM	How much do you spend per month?
Food	
Rent or building	
Transport	
Loan repayments	
Education	
other.....	
.....	

Does the household do the following?

...grow your own food?	NO	YES	
...keep animals?	NO	YES	What?.....
...catch fish?	NO	YES	
...hunt?	NO	YES	

PERCEPTIONS & PROBLEMS

Do you have **any problems** that you would like us to know about, or **any suggestions** on how to solve these problems or improve the quality of life (energy related or general)?

.....

.....

.....

THANK YOU

COMMUNAL FARMING ADDENDUM

Date..... Enumerator.....

This Quest. goes with No: H.....

Where is the land which you farm (next to house, at river, etc)?.....

Who **owns** the land where you farm?.....

What **size** is the land (hectares?)?.....

Who in the family works on the land mostly?.....

Do you **water (irrigate)** your land? | NO | YES |

Where do you get water for irrigation?.....

Do you use any **machinery** on the farm (tractor, pumps etc)? | NO | YES | What?.....

CROPS

Do you grow crops? | NO | YES | What?.....

Do you sell crops? | NO | YES |

Where do you sell crops (Kasane/Kazungula, Francistown, etc)?.....

How often do you sell crops?

sometimes	less than 1xp year	1xp year	2 or 3 xp year	1x every 2 months	every month	more

How much do you get paid when you sell?.....

STOCK (ANIMALS)

Do you keep stock? | NO | YES | What?.....

Do you sell stock? | NO | YES |

Where do you sell stock (Kasane/Kazungula, Francistown, etc)?.....

How often do you sell stock?

sometimes	less than 1xp year	1xp year	2 or 3 xp year	1x every 2 months	every month	more

How many do you sell (about)?.....

How much do you sell them for (each)? P.....

TOTAL FARMING INCOME

How much money **in total** do you think you get from farming (per year)? P.....

FARMING EXPENDITURE

What do you spend money on for farming?

ITEM	How much do you spend per year?
Fertilizer	
Seed	
Machinery	
Transport to market	
Loan repayments	
other.....	
.....	
.....	

(CHECK THAT THIS IS NOT INCLUDED IN THE EARLIER HOUSEHOLD EXPENDITURE INFORMATION)

GENERAL

Can you think of anything which would help your farming (more water, a tractor, transport...?)

.....

.....

.....

THANK YOU

ENUMERATOR QUESTIONNAIRE INTRODUCTION GUIDELINES

INTRODUCTION TO QUESTIONNAIRE INTERVIEWS

INTRODUCE YOURSELF

Your name

EXPLAIN THE PROJECT

The project aims to look at the impact of electricity on the area.
- a 'pre-electrification' study was done in 1987
- the area was then electrified
- 5 years later, we are now looking at the impact of electricity

SAY THAT WE WILL GIVE INFORMATION ON ELECTRICITY

If a house has not connected to electricity, we will provide information on what it costs to connect and how to do it as cheaply as possible.

CONFIDENTIAL

Information that you give will be kept confidential.

GIVE EXAMPLES OF THE TYPE OF INFORMATION WE NEED

Some examples of the type of information we need for the project are:
- energy used (e.g. gas, candles, electricity)
- income (important to see income & energy expenditure together)
- appliances used

TELL THEM HOW LONG IT WILL TAKE

It will take about 20 to 30 minutes.

ASK IF THEY WILL HELP

Will you help this project by answering some questions?

BUSINESS INTERVIEW GUIDELINES

Name :.....

Ownership of business & property

When business established?

Why started up?

Number of persons employed (wages?)

Electrical (& other) equipment in the business

USE ELECTRICITY

When connected?

Connection cost

Is electricity important for the business (why)?

What were you using before electricity (include **costs** of gensets...)?

Has electricity resulted in any saving?

Any problems with the electricity supply/BPC...?

What is the monthly electricity bill?

... and as a proportion of total monthly turnover (or give turnover)?

Other energy used (gas etc.) & expenditure?

DO NOT USE ELECTRICITY

Do you want electricity for the business (why)?

Why not connected?

Do you know what connection charges you would pay?

What payments do you consider reasonable (connection & monthly)?

What electrical equipment would you get if you connected?

What energy do you use (gas etc), & expenditure

OTHER

Major expenses in business (areas of expenditure, not prices)

Energy sales:
what, quantities sold, prices

Appliance sales:
what, quantities sold, prices

Plans for business in future?

GOVT/PUBLIC SECTOR INTERVIEW GUIDELINES

Name :.....

Function of institution/office

When established in Kasane?

Number of people employed?

Connected to electricity (Y/N)?

When connected?

What electrical equipment is used?

Do you have a power backup (e.g. standby generator/UPS etc.)?

What was used before electricity?

Is electricity important for the functioning of the office (WHY)?

Monthly electricity bill?

Do you know of any plans to expand the office/institution?

ELECTRICAL APPLIANCE QUESTIONNAIRE

When did you get electricity, or move into a house with electricity?

(month, year):.....

In what area is the house ('white city' govt houses, plateau,...):

.....

Please fill in the following information on the **electrical** appliances in your house (list the appliances you bought first at the top):

The electrical appliances in your house:	When was it purchased?		Who decided to but it? (husband, wife, children, other family...)	Who uses it most? (husband, wife, children, employees, whole family...)	Who paid for it or supplied it? (husband, wife, govt, other family...)
	month (if you remember)	year			
1:					
2:					
3:					
4:					
5:					
6:					
7:					
8:					
9:					
10:					

What is the **total monthly income** from all members of the household? (tick the correct block)

P 0 - P 400	P 401 - P 800	P 801 - P 1500	P 1501 - P 2500	P2501 - P 5000	over P 5000

THANK YOU FOR YOUR TIME

APPENDIX C: LIST OF INTERVIEWS UNDERTAKEN

PRIVATE SECTOR

TOURISM
Safari Lodge
Chobe Game Lodge
Hunters/Photo Africa
Afro Ventures
Kubu Lodge
Mowana Lodge
Chilwero Lodge

RETAIL
Kasane Butchery
Northern Electrical Services
Savas Stores
Gumba Bar, Chemist
Gumba General Dealer, Restaurant, Bakery
Bergers Clothing
Hair salon, dress making, office equipment, video hire
Take-aways (4-ways)
Cool Joint
Border Store
Sesheke Bar (4-ways)
Sesheke Store (4-ways)
Bottle Store (commercial centre)
Shoe Shop (commercial centre)
TC Furnishers

WHOLESALE/DISTRIBUTION
Bert's Enterprises
Sefalana
Selekanyo
Tiger Trading

MOTOR & TRANSPORT
Petrol Station (4-ways)
Workshop (4-ways)
Petrol Station Kasane (part of Kasane enterprises)
Car Hire
Quick-fit Truck Stop
Aviation services (part of Kasane enterprises)

COMMERCIAL FARMING
Chobe Farms (actually a para-statal)
Chicken farm
Crocodile farm

OTHER
Kasane Enterprises
Barclays Bank

SMALL BUSINESS (Financial Assistance Programme)
Bakery (Mrs Masheti)
Sewing (Mrs Setlhare)
Sewing (Mrs Chika)
Sewing (Mrs Kwele)
Sewing (Mrs Danga)
Sewing (Mrs Neo)
Carpenter (Mr Mmolainyane)

INFORMAL BUSINESSES
Shop near Brigades
Shop at Kazungula (eastern side)

GOVERNMENT

Central Transport Organisation
Kazungula Police
Zimbabwe Border
Zambia Border
BDF Kazungula (2 camps)
Supplies Depot
DEMS
Prisons
Information & Broadcasting
Labour office
Justice Department
Land Board
Water Affairs
Council (Council Planning Officer)
Central Administration (District Officer Lands, District Commissioner)
Hospital
Kasane Police
Integrated Field Services
Forestry
Agriculture
Wildlife
Education
Library
Chobe Junior Secondary School
Kazungula Primary School

PARA-STATAL

Chobe Farms
Botswana Telecommunications Corporation (BTC)
Botswana Power Corporation (BPC)
Chobe Brigades

APPENDIX D: QUESTIONNAIRE SURVEY RESULTS

KASANE/KAZUNGULA electrification impact study: processed questionnaire data

1 WEIGHTINGS	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
No houses	123	215	484	145	16	983
weight	0.125	0.219	0.492	0.148	0.016	1.000

2 Water supply

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
full plumb	0	100	6	88	100	39
tap on property	26	0	47	10	0	28
communal tap	61	0	47	2	0	31
fetch from river	0	0	0	0	0	0
from neighbours	13	0	0	0	0	2
					Total:	100

3 Vehicle ownership

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
none	87	66	77	71	0	74
yes	13	34	23	29	100	26
					Total:	100

4 Where moved from

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
in Kasane area	45	15	44	27	20	35
surrounding areas	19	2	21	0	0	13
further afield	35	83	35	73	80	52
					Total:	99.87487

5 Income distribution (all sources)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	Current TOTAL	Baseline **Baseline**
P0-500	41	0	23	0	0	16	10
P500-1000	28	24	35	16	0	28	54
P1000-1500	17	29	10	26	0	17	25
P1500-2000	0	22	12	24	0	14	6
P2000-2500	3	10	8	21	2	10	1
P2500-3000	3	5	6	8	0	6	0
P3000-3500	3	7	2	0	25	3	0
P3500-4000	0	0	0	3	0	0	0
over P4000	3	2	6	3	50	5	2
					Total:	100.2889	100

6 Education (typical household education profiles)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
none	40	4	35	13	20	25
primary	28	11	29	8	14	22
secondary	26	74	35	58	44	46
tertiary	6	11	2	21	22	8
					Total:	100.4924

7 House construction material (main structure)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
brick/block	53	100	67	100	100	78
zinc	9	0	4	0	0	3
mud	31	0	13	0	0	10
wood	3	0	1	0	0	1
reed	3	0	15	0	0	8
					Total:	99.87487

8 Number of buildings & rooms per household

(number)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
buildings	3.2	1.1	3.7	1.1	1.4	2.6
rooms	4.5	5.9	5.2	5.4	8.6	5.4
					Total:	*

9 House ownership

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
self/family	91	14	88	2	60	59
govt	5	82	1	98	0	34
rented	4	2	10	0	20	6
company	0	2	0	0	20	1
					Total:	99.50763

10 Number in house

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
persons	5.6	2.6	5.9	3.1	3.4	4.7
total population	**689**	**559**	**2856**	**450**	**54**	4607

11 Were you in the Kasane area (not house) before '87?

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
yes	74	14	76	18	60	53
no	26	86	24	82	40	47
					Total:	**100**

12 How long have you been in this house?

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
under 1yr	6	22	6	45	20	15
1-2yrs	9	43	8	28	20	19
3-5yrs	12	23	13	15	20	15
6-10yrs	13	9	10	10	0	10
over 10yrs	59	2	63	3	40	40
					Total:	**99.80366**

13 Why did you move here?

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
no reason	7	4	3	3	0	4
employment	27	83	39	88	80	55
other	13	0	11	3	0	7
came to family	36	0	15	0	0	12
own accomodation	13	11	7	6	0	8
born here	3	2	27	0	20	14
					Total:	**100.8596**

14 Average household income per source

(Pula)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
formal	678	1601	1145	1635	17550	1526
informal	278	8	231	53	200	151
agriculture	25	27	10	0	0	14
average	999	1612	1467	1692	17800	1739
median	600	1400	742	1600	4500	1056
					Total:	

15 Income sources (households receiving income from each source)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
formal	93	100	100	100	100	99
informal	47	4	37	5	20	26
agriculture	23	4	15	0	0	11
					Total:	

16 Employment - average persons per household (includes all in hh)

(persons/hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
self employ	0.13	0.06	0.16	0.09	0.6	0.1
skilled employ	0.22	0.15	0.16	0.39	0.8	0.2
unskilled employ	1.78	1.62	2.23	1.1	0	1.8
unemployed	3.84	0.83	3.56	1.44	2.4	2.7
SUM employed	*2.13*	*1.83*	*2.55*	*1.58*	*1.4*	2.2
					Total:	**4.844507**

17 Male & female (total population)

(% persons)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
male	48	61	46	42	41	49
female	52	39	54	58	59	51
					Total:	**100**

18 Age - over 15 yrs & under 15 years (total population)

(% persons)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
over 15yrs	64	79	71	66	69	71
under 15yrs	36	21	29	34	31	29

19 Informal business - household involvement therein

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
no inf. bussiness	52	94	56	88	60	69
with inf. business	48	6	44	12	40	31
					Total:	**100**

20 Informal business - which is the household involved in?

(% hh with buss)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL	total sample
brick make	0	0	0	0	0	0	0
sewing	0	0	6	0	0	3	0.9
basket make	0	0	3	0	0	1	0.5
fishing	0	0	3	0	0	1	0.5
beer make	33	0	34	0	0	21	6.6
tailor	7	0	0	0	0	1	0.3
food selling	7	0	3	100	0	17	5.4
small shop	47	100	41	0	0	48	15.1
business general	7	0	3	0	100	4	1.3
other	0	0	6	0	0	3	0.9
					Total:	**99.63276**	

21 Electricity use in informal businesses

(% of inf. buss.)	all areas	TOTAL
brick make	0	
sewing	0	
basket make	0	
fishing	0	
beer make	0	
tailor	0	
food selling	14	
small shop	28	
business general	57	
other	0	

(7 out of 56 businesses encountered use elec) **Total:**

22 Informal businesses using electricity - elec used for what?

(% bussinesses)	All areas	TOTAL
appliances	33	
lights	17	
appl & lights	50	

Total:

23 Agriculture - household involvement

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
keep crops	34	11	34	5	0	24
income from crops	9	2	16	5	0	10
keep stock	28	13	31	5	0	22
income from stock	6	9	10	2	0	8

Total:

24 Family roles - who collects wood?

(% hh)	all areas
women	30
men	37
youth	5
whole family	22
others	6

24 & 25 combined

	collect wood	work land
women	30	53
men	37	18
youth	5	0
mixed/oth	28	28

25 Family roles - who works farm lands?

(% hh)	all areas
women	53
men	18
youth	0
elderly	8
others	20

26 Monthly expenditure & disposable income - non energy goods

(Pula/hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
Av expend	364	917	403	598	2567	575
Av income	999	1612	1467	1692	17800	1739
Av disposbl. inc	**635**	**695**	**1064**	**1094**	**15233**	**1165**
Median expend	218	655	270	400	2540	404
Median income	600	1400	742	1600	4500	1056
Med. disp. inc	**382**	**745**	**472**	**1200**	**1960**	**652**

Total:

27 Energy expenditure (those using the fuel)

(Pula/hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
electricity	300	53	67	48	152	92
paraffin	10	4	9	9	0	8
gas	26	24	49	38	37	39
candles	12	0	11	12	0	9
batteries	20	8	34	36	5	26
car batts	6	2	7	0	14	5
genset	0	0	168	0	0	83
wood	26	0	68	0	0	37
AVERAGE	47	70	102	72	106	84

Total:

28 Energy expenditure (total sample)

(Pula/hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
electricity	9	47	4	36	133	21
paraffin	6	0	7	1	0	4
gas	4	22	24	32	22	22
candles	8	0	7	1	0	5
batteries	14	2	26	3	1	15
car batts	1	0	1	0	3	1
genset	0	0	2	0	0	1
wood	5	0	32	0	0	16
AVERAGE	47	70	102	72	106	84

Total:

29 Energy expenditure by income group

(Pula/hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
P0-500	26		53			48
P500-1000	49	49	82	42		64
P1000-1500	47	70	196	74		131
P1500-2000		53	111	77		78
P2000-2500	25	41	92	76	29	69
P2500-3000	52	69	215	72		140
P3000-3500	32	140	11		45	48
P3500-4000				55		55
over P4000	361	455	110	138	129	221
					Total:	

30 Energy expenditure by income group

(% of tot income)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
P0-500	17		21			20
P500-1000	7	7	13	5		10
P1000-1500	4	6	15	7		10
P1500-2000		3	7	5		5
P2000-2500	1	2	4	4	1	3
P2500-3000	2	3	8	2		5
P3000-3500	1	4	0.3		2	1
P3500-4000				2		2
over P4000	6	10	2	3	1	4
AVERAGE	10	5	12	5	1	9
					Total:	

31 Energy expenditure - households with & without electricity

(Pula/hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL	
Inc-elec users	6483	1612	1310	1740	21733	2419	
Expend-elec users	361	72	110	79	118	129	Kazungula only one household
Expend-non elec	none	none	196	23.5	57	101	only SHHA figures reasonable
(in same inc. group)					**Total:**		

32 Energy expenditure - perceived cost vs actual expenditure (incl. vehicle fuel)

(Pula/hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
perceived	125	182	119	132	393	140
actual	68	145	94	100	310	106
					Total:	

33 Energy sources used by households

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	Current TOTAL	Baseline Baseline
electricity	3	100	8	88	80	40	0
paraffin	62	2	75	13	0	47	72
gas	19	92	55	97	80	65	22
candles	66	0	64	5	0	41	56
batteries	75	19	80	8	20	54	33
car batts	19	2	10	0	20	8	0
genset	0	0	1	0	0	0	1
wood	100	32	88	32	0	68	77
					Total:		

34 Energy sources used for?

(% hh)	light	cook	heat	radio	TV	hi-fi	heat wate	torch	iron	fridge	electronic equip.
electricity	99	8	7	66	27	6	7	0	29	30	0
paraffin	98	38	1	0	0	0	0	0	1	0	0
gas	2	99	8	0	0	0	3	0	4	9	0
candles	100	0	0	0	0	0	0	0	0	0	0
batteries	18	0	0	86	0	1	0	16	0	0	1
car batts	0	0	0	75	0	25	0	0	0	0	0
genset	100	0	0	0	0	0	0	0	0	0	0
wood	0	100	0	0	0	0	0	0	0	0	0

35 Quantities of fuels used by households (those using the fuel)

(quantity/hh/mth)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
paraffin (litres)	9	4	8	8	0	7
gas (kg)	13	9	19	14	15	15
candles (No.)	25	0	24	23	0	18
car batts (chrgs)	4	0	10	0	2	
genset (litres)	0	0	140	0	0	69
wood (kg)	111	98	108	65	0	98
					Total:	**207.7365**

36 Quantities of fuels used by households (total sample)

(quantity/hh/mth)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
paraffin (litres)	6	0	6	1	0	4
gas (kg)	2	8	10	13	9	8
candles (No.)	17	0	14	1	0	9
car batts (chrgs)	1	0	1	0	0	1
genset (litres)	0	0	2	0	0	1
wood (kg)	104	4	82	5	0	55
					Total:	

37 Wood use (those using wood)

(% hh or hours)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
only collect	53	78	23	88	0	48
buy wood	47	22	77	13	0	51
collection hrs/mth	20	1	10	0.4	0	8
					Total:	

38 Wood use - problems getting wood (those using wood)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
far away	29	0	34	0	0	20
wild animals	43	71	14	60	0	37
expensive	0	0	9	0	0	4
scarce	0	14	2	0	0	4
combination	7	0	26	0	0	14
other	7	0	2	0	0	2
no problems	14	14	12	40	0	17
					Total:	

39 Electricity expenditure & use vs time electrified

(Pula/mth or kWh)	expenditure	kWh/mth		TOTAL
0-6 mths	59	195		
6-12 mths	52	169		
12-18 mths	40	124	most people moved into electrified houses	
18-24 mths	49	157		
24-36 mths	61	202		
36-48 mths	82	281		
48-72 mths	26	71		
over 72 mths	193	697		
			Total:	

40 Electricity - what are considered reasonable connection and monthly payments?

(Pula)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
connection	1044		725	200	1000	683
monthly	70		66	50	250	67
					Total:	

41 Appliance energy source (those owning the appliance)

(% hh)	stove/htplt	fridge	freezer	light	iron	kettle	TV	hifi/radio	kitch.appl.	powr tools	aircon	fan	
electricity	4	75	77	51	51	30	100	51	100	100	100	10	
gas	69	21	23	2	2	6	0	0	0	0	0		
paraffin	16	0	0	30	2	2	0	0	0	0	0		
wood/other	7	0	0	0	35	45	0	0	0	0	0		
batteries	0	0	0	0	0	0	0	47	0	0	0		
>1 energy source	5	5	0	14	10	16	0	2	0	0	0		
candles	0	0	0	4	0	0	0	0	0	0	0		

Electricity weightings

	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
total No. hholds	123	215	484	145	16	983
% with elec	3	100	8	88	80	
No. with elec	4	215	39	128	13	398
with weight	**0.009**	**0.540**	**0.097**	**0.321**	**0.032**	**1**
% without elec	97	0	92	12	20	
No. without elec	119	0	445	17	3	585
without weight	**0.204**	**0.000**	**0.761**	**0.030**	**0.005**	**1**

42 Problems with electricity (electricity users with problems)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
no problems (NO)	*0*	*66*	*67*	*67*	*100*	*67*
problems (YES)	*100*	*34*	*33*	*33*	*0*	*33*
expensive	100	29	50	33	0	32
power failures	0	57	50	67	0	57
appl. expensive	0	7	0	0	0	4
power surges	0	7	0	0	0	4
					Total:	96.78238

43 Benefits of electricity (elec users saying that they have benefitted)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
no benefit	*0*	*8*	*0*	*6*	*0*	*6*
benefited	*100*	*92*	*100*	*94*	*100*	*94*
better lighting	0	0	67	19	0	13
watch TV	0	0	0	0	0	0
safer energy	100	5	0	0	0	4
always available	0	7	0	0	25	5
appl. availability	0	72	17	57	75	61
cheaper	0	16	17	24	0	18
					Total:	100.0973

44 Changes in energy expenditure due to electricity

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
more	0	34	33	28	25	31
less	100	48	67	63	25	54
little change	0	6	0	3	0	4
don't know	0	12	0	6	50	10
					Total:	100

45 Electric appliances - want to get (THOSE WITH ELECTRICITY)

(% hh)	stove/hot plt	lights	TV	hifi/radio	iron	kettle	fridge	freezer
choice 1	6	0	50	6	2	10	25	0
choice 2	4	4	33	13	8	13	21	4
choice 3	0	0	0	20	0	40	20	20
choice 4	67	0	0	0	0	33	0	0

46 Want electricity - reasons (those without electricity)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
don't want	*29*		*14*	*33*	*0*	*18*
want	*71*		*86*	*67*	*100*	*82*
no reason	9		0	0	0	2
TV	5		0	0	0	1
appl. availability	23		64	50	100	55
cheaper	9		5	0	0	6
better light	41		26	50	0	30
for business	14		2	0	0	4
other	0		3	0	0	2
					Total:	100.2039

47 Why not connected? (those without electricity)

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
no reason	4		0	0	0	1
expensive	79		85	0	0	81
not my house	13		3	100	0	8
intend to	4		12	0	100	10
					Total:	100

48 Electric appliances - want to get (THOSE WITHOUT ELECTRICITY)

(% hh)	stove/hot plt	lights	TV	hifi/radio	iron	kettle	fridge	freezer
choice 1	26	18	14	4	5	0	30	3
choice 2	24	8	24	13	7	0	23	1
choice 3	9	12	12	17	21	5	24	0
choice 4	14	14	14	8	36	0	11	3

49 General problems/suggestions

(% hh)	Kazangula	Plateau	SHHA	Govt	Pvt river-front	TOTAL
education avail.	13	2	22	13	20	19
elec expensive	34	14	28	0	0	28
food/goods expensiv	9	12	10	13	20	10
employment needed	16	0	19	0	0	18
plot/accomodation	9	2	11	0	0	11
game dangerous	0	12	5	0	0	4
need street lights	0	8	6	5	0	5
wood scarcity	6	2	6	0	0	6
more shops	0	10	0	0	20	0
recreation/entertainm	0	8	0	5	0	0
malaria	0	2	4	3	0	3
water supply	13	0	1	0	0	4
gas,etc availability	6	0	1	0	0	2
crime/theft	0	2	3	0	20	3
other	25	24	11	12	20	14
					Total:	

50 FARMING: General problems/suggestions

(% farmers)	all areas
tractor to plough	43
game in fields	41
water supply	34
animal disease	11
more land	7
fertilizers/seed	7
other	5